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Design Concepts for Zero-G Whole Body Cleansing on ISS Alpha

Part II: Individual Design Project

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September 2001

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Preface

This document, originally published at International Space University in 1997, was a Master of Space Studies student's project. While the specifics concerning the (not-yet-built) space station may be a little dated, the research results gleaned are still relevant and valid. Therefore we are publishing it as a NASA Formal Series document in an effort to make the data available.

This project has been carried out in the Flight Crew Support Division of NASA's Lyndon B. Johnson Space Center, Houston, Texas, USA, under the guidance of Dr. Frances Mount.

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1 Abstract

1.1 The abstract

Johnson Space Center, the *Mecca* of manned Space Programs, is now abuzz with preparations for the International Space Station—ISS Alpha. The work on the various systems and subsystems for the U.S. Habitation Module is scheduled to begin in l998. As a prelude to that, the Flight Crew Support Division perceived the need to take a closer and more critical look at the planning for the Whole Body Cleansing function onboard the ISS.

This report is an endeavour to dig and delve all data available on Whole Body Cleansing mechanisms used in the past and the present, by the Russians and the Americans, analyze it and come up with design concepts for products/ product systems for Zero-g Whole Body Cleansing onboard ISS Alpha, for typical stay duration of about 90 days.

This report takes a close look at the Skylab collapsible shower, the Mir shower/ sauna, the full body cleansing methods currently in use onboard the Space Shuttle and Mir and at the Whole Body Shower designed and tested for Space Station Freedom. It attempts to "listen" carefully to what the Mir astronauts—Norman Thagard, Shannon Lucid and John Blaha—have to say about their personal hygiene experiences during their recent long-duration stays on the Russian station Mir. The findings in the report call for a change in paradigm. What is good for Earth conditions is not necessarily good for Zero-g! It concludes that a shower is not a good idea for the ISS. The final concept that is proposed reflects very strongly what the Mir astronauts would like to have and to use onboard a station like the ISS. The report concludes with directions of how to take the "idea" further and realize it in the form of a product system for Whole Body Cleansing onboard the ISS.

2 Introduction

2.1 The problem

In the **weightlessness** of Outer Space, performing tasks that are considered ordinary, simple and routine on Earth can sometimes become problematic, difficult, frustrating…perhaps even funny!

A simple task like **taking a shower** that would take let's say, just 5 minutes on Earth might take a daunting 1 whole hour, even more! Besides, after each shower the astronaut needs to not just mop/vacuum himself dry, but also lavish the same treatment to the shower enclosure and that is most undesirable because by the time he would finish both, he would end up cold and uncomfortable!

Also, one simply cannot allow any water droplets from floating around and getting into equipment onboard or for that matter into the eyes or into lungs of the crew onboard and put their health in jeopardy! Besides, the crew cannot spend valuable time vacuuming escaping/floating water from the air and the installations onboard!!

On the other hand, "personal hygiene" is indispensable to keep the astronauts in good shape and in good spirits!…in other words, for psychological and physiological reasons. The solution lies in designing appropriate products for all aspects of living and working in an alien weightless environment…and that includes products in the category of "crew hygiene". Needless to say, these products or product systems will have a pervasive influence on the life of the crew...their living standards, their working habits ... their overall well-being. And all that is vital to the success of our Space missions.

While designing for Zero-g conditions, one cannot and one should not be bound to "Earth paradigms"; one needs to develop one's perceptions of the conditions of a weightless environment, one **also** needs to **listen carefully to what the astronauts from the long-duration Space stays have to say from their experiences** of living and

working in Space. All this is vital to the design process of any Space product or environment and the design concepts for Zero-g Whole Body Cleansing will be no exception to this rule if we are to provide Whole Body Cleansing mechanisms onboard our International Space Station that will be liked and used by the crew onboard.

3 Design Brief

3.1 The design brief

"The work on the various systems and subsystems including those for Personal Hygiene onboard the U.S. Habitation Module for the International Space Station (ISS) Alpha is scheduled to begin in 1998.

Look into the existing and planned systems as well as methods for Zero-g Whole Body Cleansing used on Space stations and freighters. The Skylab crew utilized a collapsible shower that was found to be not optimum for extended missions. The Mir crews used a shower for several years that was found to be less than optimum. The Mir shower was used as a sauna in the last 2 years of its existence onboard before it was disposed off (to make space available onboard Mir, for a gyrodyne, in 1995) in the Progress spacecraft to be burnt in the atmosphere during re-entry. ISS will include a full-body cleansing function, which has been assumed to be a water spray shower. Based on Russian inputs, this may not be the best solution.

Evolve design-concepts for Zero-g Whole Body Cleansing for long-duration missions which can be used for international crews onboard the U.S. Habitation Module of ISS Alpha."

4 Skylab

4.1 The Skylab collapsible shower

- A deployable, collapsible shower was provided in the experiment compartment of the Skylab.

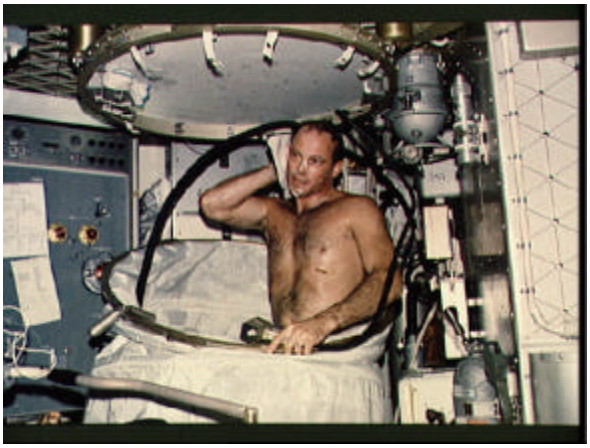


Figure 4.1a Whole Body Shower onboard Skylab

- The **shower** aboard Skylab was considered a pleasant experience but was very **time** consuming, about **45 minutes** from start to finish.

- The Skylab shower was an enclosure that used continuous airflow as a gravity substitute to move the water over the crewman. However, airflow through the shower was insufficient to prevent water retention on the crewmember. Some water was also retained on the shower walls as well.

- A 6 pound capacity water bottle was filled from the Waste Management Compartment (WMC) water heater, pressurized with nitrogen, and attached to the grid ceiling at the shower location.

  The nitrogen gas pressurant expelled water from the bottle through a transfer hose and a crew-operated hand-held spray nozzle.

- A soap dispenser provided the crewman with 8 millimeters of liquid soap for each shower. During the shower, this dispenser was fastened to the ceiling with Velcro.

  A suction head removed water from the crewman and the shower interior. The suction head was connected by hoses to the centrifugal separator, which deposited the wastewater into a collection bag. A blower pulled the air from the separator through a hydrophobic filter that protected the blower.

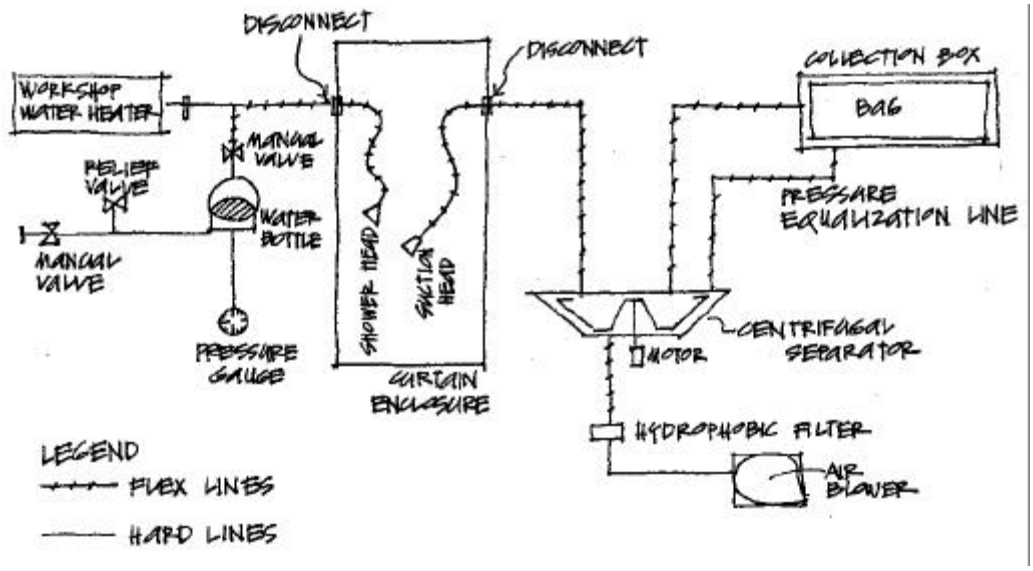


Figure 4.1b Shower system schematic

4.2 Other elements of the Skylab PHS

- Personal hygiene for the Skylab crewmembers was supported in the Waste Management Compartment (WMC). The WMC included:
  - a **fecal/urine collector**,
  - a **handwasher**,
  - **stowage** for personal hygiene items and
  - a **drying station**.

- Each crewmember was provided supplies for personal care and grooming.

- The **fecal/urine collector** provided for both urination and defecation. Urine was collected into an inlet cone (only men were aboard Skylab). For defecation, a fecal bag was installed in the fecal collector mounted on the wall of the WMC. The use of a lap belt during defecation was considered essential.

- Approximately 2 wipes were used after each defecation and placed in the fecal bag. Then the bag was sealed and placed in the waste processor for vacuum drying.

- The **handwasher** was recessed in the WMC wall. Washing hands was difficult because of water splatter. Alternatively, crewmembers would use the water source in the handwasher to wet a washcloth for body cleansing. The handwasher also provided a squeezer which removed excess water from washcloths into a bag.

- The **drying station** provided cruciform slit utility restraints. Towels and wash cloths were restrained here to dry for future use. **The figure below shows the towel and washcloth drying restraints aboard Skylab.**

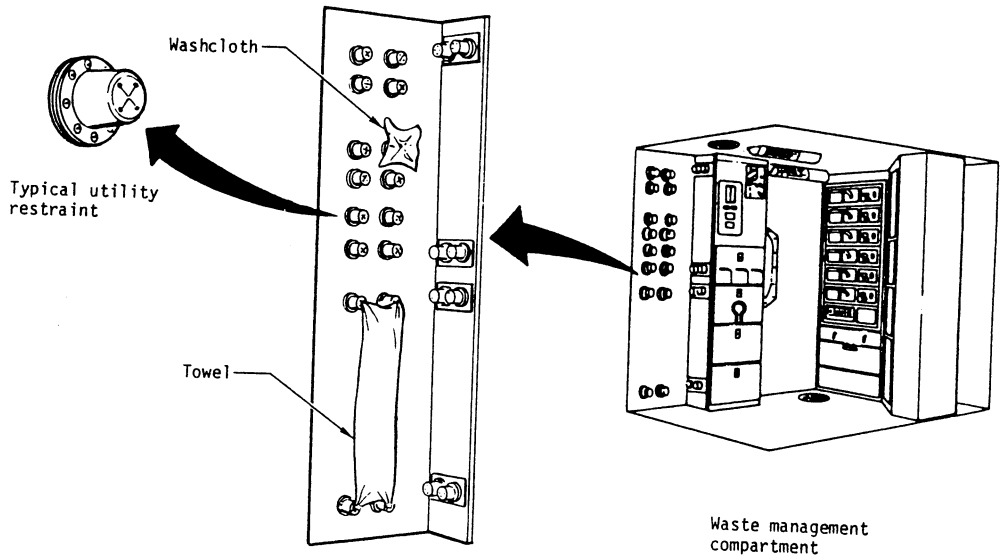


Figure 4.2a Towel and washcloth drying restraints

- Standard non-personalized kits were provided for all crewmembers. Hygiene items were restrained in the kits with elastic straps. Included in the kits were the following items:
  - **windup shaver**
  - **safety razor**
  - **razor blades**
  - **shaving cream**
  - styptic pencil
  - safety swabs
  - **hair brush and comb**
  - **trim comb**
  - nail clippers
  - **toothbrush**
  - **toothpaste**
  - emollient
  - antiperspirant stick
  - **mirror**

Towels, washcloths and **wipes** were provided for cleaning and drying. The flame retardant caused the towels to be less soft and not as absorbent, to the frustration of the crew.

The toothpaste was ingestible but due to taste, crewmembers preferred to spit into a wipe.

The trim comb was used with comb and scissors for haircuts.

Nails were trimmed in the WMC so that clippings were caught by the ventilation screen.

Shaving was difficult and time consuming, and some crewmembers chose to let their beards grow.

Bar soap was used with the handwasher and liquid soap was used in the shower.

5 Mir

5.1 The shower on Mir

- **The shower In the Kvant 2 module of Mir was removed in April 1995 to make room for a gyrodyne.**
- It was used as such until two years prior to removal at which time it use was limited to saunas only.
- Air flow carried water to the shower bottom into a separator where hydrophilic surfaces and centrifugal devices were used for **air-water separation**.
- When used as a shower, hot (40 to 45 degrees Celsius) and ambient **water** can be **mixed for temperature selection**. Air temperature was controlled at 35 to 43 degrees Celsius, and velocity was 0.5 to 1 meter/second.
- **Minimum water consumption 2.5 kilograms**
- Rate of water consumption 0.2 to 1.9 kilogram/minute
- **A cosmonaut would on an average spend about 45 minutes for the shower and pre/post shower operations** like actuating the systems for heating bath water and disinfecting the shower.

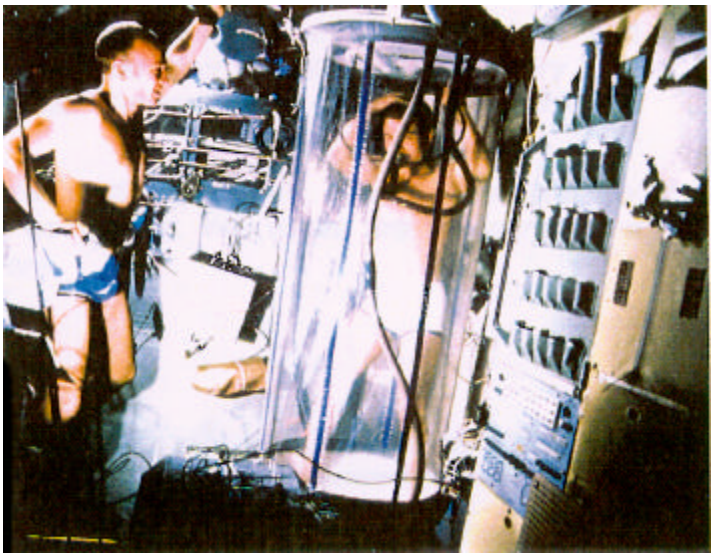


Figure 5.1a A prototype of the Mir shower

- To disinfect the shower, it was heated to 60 degrees Celsius for 2 hours with hot air flow.
- **Power consumption** by the shower unit **for air and water heating** during a shower was 1 kW.
- There was no water suction wand to remove excess water, so toweling was the only method for removing water that clung to the shower enclosure and the crewmember.
- An alkaline liquid cleanser for shower included the active ingredient amine oxide-alkyldimethylbenzylammonium chloride. It produced almost no foaming and could be impregnated into washcloths and mittens.
- A bag for hair washing contained a special non-soap shampoo and wipes for removing the shampoo from the scalp.

5.2 The shower as a sauna

- About 2 years prior to removal of the shower, crewmembers used the shower enclosure for an air shower (sauna) about once a week, with warm or hot air flow, followed by a rubdown with a moist towel.
- To use as a sauna, the fan and heater were turned on. This mode requires no waiting for water to heat, and there is less cleanup of water afterward.

5.3 Full body cleansing as done now on Mir

- Full body cleansing is accomplished using wipes and towels. Crew are allotted 3 towels per day, 1 wet towel and 2 dry towels. These are pink bath sized towels. Wet towels are damp with no additives.
- In addition, **wet and dry wipes, gauze material** about washcloth size, are available as needed. Wet wipes are impregnated with a special lotion and disinfectant.

5.4 Other elements of the Mir PHS

- The Mir Personal Hygiene Subsystem consists of
  1. **toilets** for body waste management,
  2. a **handwash units** and **shower** (now removed)for full and partial body cleansing,
  3. **personal hygiene kits** for personal grooming and care.

  Two personal hygiene enclosures, one located **in** the **Mir core module and the other in the Kvant 2 module,** enclose a toilet and a handwash unit. The core module toilet has been mothballed, but is available as a backup.
- Each toilet has two urinal hoses for sitting or standing urination for men and women. The toilet has a fixed urine cup attached to a flexible hose as the design is not intended for physical contact with the cup. No additional absorption devices for urine are provided for emergencies or EVA.
- The handwash units have transparent enclosures with rubber-lined openings for hands and face. Each use nominally consumes 0.3 liters of water from the built-in dispenser.

  For use, the crewmember inserts hands and face into the washer. A sprayer and temperature mixing valve are located inside it.

  Airflow is used to remove the wastewater. The unit is wiped off with a special cloth after use, and requires cleaning after several uses. After every 24 uses it is cleaned with a disinfectant.

However, the handwash units are no longer used. Instead crewmembers use wash cloths wetted with water from the Rodnik water dispenser.

- Personal hygiene items are provided in a soft kit which can be attached to the wall. At least the following items are provided:
  electric razor
  safety razor
  blades
  shaving cream
  after shave
  comb
  nail clippers
  toothpaste (with tethered caps)
  toothbrush

  Items are secured in the kit with pockets and other means so that upon opening they don't float away. But some items, such as combs, occasionally do escape from the kit.

  For **oral hygiene**, crewmembers can use a toothbrush with forced water and toothpaste supplies. There is a mouth ejector for removal of waste, but crewmembers just use tissues and expectorate into them when brushing teeth.

  Crew can also use fingercots impregnated with toothpaste rather than using a toothbrush with added toothpaste.

  Toothpicks and chewing gum are also supplied. Chewing gum is supplied for use twice after meals daily to aid in the removal of food particles from the teeth.

  Grooming of nails can be performed in the handwash unit. **Shaving** can also be performed in the handwash unit or using an electric shaver with a suction hose attached. **Hair cutting** can be performed with a clipper on a vacuum cleaner suction hose.

6 Feedback From Mir Astronauts

6.1 Feedback from Norman Thagard

Here are excerpts from Norman Thagard's experience of the Personal Hygiene System onboard Mir during a long-duration stay of several months.

Q. We understand that, during your mission, the shower or sauna was removed. Did you have a chance to take a sauna before it was removed?
N. I used the sauna one time, because I wanted to say that I had done it. Then it was chopped up, literally, with a machete from the Soyuz survival kit. The sauna was too big to fit through the hatches and into the Progress without chopping it up. It was nice, but it certainly wasn't something I felt I had a driving need to do.

The hygiene system was composed of handwipes in dry and wetted form. The towels were cloth towels. They came in cellophane bags. You were allotted one wet towel and two dry towels a day, and I found that to be an excellent system. The only complaint I would have is you should have had two wetted towels a day, because you were scheduled for two 1-hour exercise sessions. I found that I was having to use the dry towels and then squirt water in them for the second exercise session, and that is not nearly as convenient as using these pre-wetted towels.

Q. Are you saying that if the sauna weren't there, you wouldn't have missed it at all?
N. I wouldn't have missed it.

Q. How about the Russian crew?
N. They would have missed it.

Q. They found favour in it?
N. Oh yeah! Volodya used it a lot. I don't think Gennady used it all that much, but Volodya did enjoy it. Russians feel very strongly about their saunas.

Q. And you felt that the system of wipes adequately handled full body cleansing?
N. The pre-wetted towels, yes. I felt they were superior to what we have on Shuttle, where we have washcloths and towels that you have to wet. That's never going to work as well as having these pre-wetted towels.

Q. Given your experience, what hopes would you have for a shower on the USOS?
N. It would be nice to have a shower, but if the shower's going to be at the expense of a huge operational overhead, I don't think it's going to get much use. If I knew that I was going to have to spend 30 minutes. for instance, cleaning up a shower after I used it, that would probably deter me from using it, I would think. No, a shower would be extremely desirable as long as it had low operational overhead.

Q. Did the sauna have an operational overhead?
N. Not much.

Q. It didn't take much cleaning?
N. No. Just turn on the fans and the heaters and go.

Q. If you were given a choice on the USOS of there being a sauna or not, your recommendation would be no sauna?
N. My recommendation would be to poll the other folks because I don't think my one opinion is adequate.

Q. When you used the sauna, did it significantly modify the humidity level in the station?
N. No.

Q. Was the shower capability in the Mir sauna entirely disabled or was it just not used?
N. It was not used.

Q. They could have operated it as a shower when you were there?
N. I am sure they could, because nothing had changed in the hardware.

Q. I have heard that the water regeneration system from sanitary hygiene water had not been as effective as they had thought it would be.
N. Could be.

Q. Where did you perform full body cleansing-
- **in the crew quarters,**
- **in the hygiene compartment or**
- **in the sauna enclosure?**

N. Either in the toilet area, which was certainly where Volodya always did it. In fact, the wetted towels were stowed in cloth bags right outside this toilet area. I either used the toilet area or my little sleep station.

Every 3 days, you get this so-called sports underwear, but basically it is a lot more like a regular old T-shirt and a pair of running shorts. What you do is you wear this one set, and at the end of 3 days, that set becomes one of your two exercise outfits. Since one might exercise twice in a day, I would normally keep a couple of old pairs as my exercise gear and, on a given day, I never had to put on wet sports clothes.

Q. For your personal hygiene, did you use a NASA supplied kit?
N. I did though there were Russian supplied kits. The one thing that was in the NASA kit that I really liked was the soapless shampoo.

Q. How often did you use the shampoo?
N. Early in the mission, I tended to use the shampoo about once a week.1 was worried that it wouldn't last the whole mission. After a while it was pretty clear that it would last longer than I thought, so I'd use it a couple of times per week, especially if I knew there was going to be TV to the ground.

Q. Did you try all the articles in the Russian personal hygiene kit at one time or the other?
N. I used their plug-in electric shaver. Apart from that, I didn't use much of the Russian gear since I had my own US supplied kit.

I think we ought to look into their system of personal hygiene: I found it to be a good one. We ought to consider supplementing it, so that you can get two of those wetted towels a day instead of just the one.

Q. Are there any items in the Russian kit that you did not think would be functional?
N. No. I thought it all worked, but then why use it when I already had something with which I was familiar.

Q. Did you also have the NASA shaver or just the Russian one?
N. Yes, I had the NASA shaver and it worked fine. About a week before the Shuttle got there, however, I was trying to tap out the hairs that accumulate in a shaver and it flew apart. I never found all the parts.

Q. You felt that if you were supplied only the Russian personal hygiene kit, it would satisfy all your needs?
N. Yeah. They provided everything. But obviously, your preferences are for things with which you're familiar. Since I had the US kit that was identical to kits I have flown on previous flights, that's what I used.

Q. Do you have any comments comparing the Russian provisions to your past experience with the Shuttle provisions?
N. For the crew stuff?

Q. Yes.
N. You could go up there and do all right with the Russian stuff.

Q. Were the wetted towels just wetted with water, or was there some formulation that was used?
N. Volodya told me that in fact there were other chemicals in it. I was told I shouldn't just leave the wetted towels out to dry, because there were some volatiles in them that would affect the atmospheric regeneration system over time. I usually put them back in the cellophane bags, and then threw them in the trash.

Q. What about washcloths? Were they also wetted?
N. We didn't really have washcloths; we had little wipes. They were just like the towels; there were dry varieties and wet varieties. They were like little gauze pads...like little gauze squares.

Q. How many of these little wipes did you get in addition to the towels?
N. There was no restriction on the number of wipes.

Q. How about the Russian shampoo?
N. Well, I was told when I left that there was already some soapless shampoo onboard, though I never found it. I remember Gennady asked to borrow my bottle of NASA shampoo a couple of times. I had two bottles. I wound up giving one of them to Gennady. So even though we were told there was some Russian shampoo already onboard, Gennady didn't know where it was and neither did I.

Q. The NASA shampoo came in a bottle?
N. It came in little plastic cylinders.

6.2 Feedback from Shannon Lucid

Here are excerpts from Shannon's debrief after her return from a 188-days stint onboard Mir. She replaced Norman Thagard and in turn was replaced by John Blaha.

Q. Moving on to personal hygiene. Were supplies adequate? Was there anything that you would have preferred to have seen that you didn't have in the hygiene kit? Did you prefer the Russian hygiene kit or the American one? Could you elaborate on that?
S. I was happy with what we had. Unfortunately we ran out of stuff in August. We ran out of dry towels. Dry towels were nice, but we ran out. You could use wet towels as dry towels, but it made it hard when you were cleaning hair, because it just didn't dry up the rinse-less shampoo as well. And you could make the wet towels dry out and use them as dry towels, but they had a residue on them because they had some kind of a cleaning agent. We just didn't understand why we had all these wet towels. Then when Progress came we had more wet towels, no dry towels and no little wet wipes. We didn't quite understand that.

They have a shirt and a little cotton knit type short. I changed one of those halfway through the week. I used two a week, until we were running real low and then we went

to one a week. Then the blue jumper that I wore everyday--I wore the same one everyday for 188 days. Also, I was surprised it didn't get.....

Q. It didn't stand up by itself?
S. It might have. It was pretty stiff, but it worked out O.K. Then I used both the American and the Russian shampoo .... the rinse-less shampoo. I really couldn't tell any difference. I didn't prefer one or the other. They were both nice. It made your hair not oily. I just thought it would be good to use 2 different ones, You know, not to have the same chemical in your hair all the time.

Q. You used Russian pre-wetted towels?
S. Yes, a couple of times a week. And then I had lots of U.S. body baths, you know those silver things. The Russians loved those too. And so I would use about one of those baths a week, because I would fill it up and then just refill it and use it. Those just worked out real nice. After exercise, I would just take a handful of the water and put it around and take a towel and wipe it off. I felt clean.

Q. We had some comments from Norm on preferences on the shower versus the sauna on ISS. Due you have any feeling pro one or pro the other? Obviously, the shower is not there...
S. Frankly, I don't think that I would want either one because it would be too much of a mess to clean up. That's just my own personal preference, I would rather take a wet towel or just use a handful of water like I did than have to clean up something afterwards. I guess I am sort of lazy. And I felt clean, and I know it cleaned the guys up. After exercise, (because you know you can tell when a person has exercised), they would go wipe themselves off with a wet towel or use the body bath. and you could tell that they were nice and fresh.

Q. Clean?
S. Yes. I thought it to be totally adequate.

6.3 Feedback from John Blaha

John Blaha was the third American astronaut to stay onboard Mir for several months. He said that, with time, he "adapted" and "learnt" how to take a good shower in Space during his long-duration stay onboard the Mir Space Station.

He used the U.S. Personal Hygiene Kit for 95% of the time and thus did use the one the Russians gave him, but very little.

When asked to comment on "the Russian pre-wetted towels" versus "the American method of wetting towels", he responded saying, "The Russian prewetted towels were wonderful. After a workout they were good for a quick bath. I loved them. They were fantastic."

When it was time for a "real bath", he would first apply a beat of soap from the American pouch wash, and then apply a beat of water using the American drink bag and then rub with a damp towel. At the end of this exercise, he said, "I felt very clean. It felt like a real shower. I used the pre-wetted towels and wet wipes at ambient temperature."

John Blaha pointed out that the pre-wetted stuff that they were provided onboard Mir was excellent, but for some people they proved to be uncomfortable due to the fact that they had to used at ambient temperature which for them was "cold". So he said it would be a good idea if one could heat that stuff up to a desired/comfortable temperature before use.

He said that before returning to the Earth, he showed the next American astronaut, Jerry Linenger (who replaced him on Mir for the next long-duration stay) how to take a shower in Space without a shower.

7 Space Shuttle

7.1 Full body cleansing on Shuttle

- The Shuttle crew can sponge-bathe with the Personal Hygiene System (PHS) hose (20 feet long) located in the Waste Collection System (WCS) compartment. Water is squirted onto a washcloth using the hose.

- Crew prefer to use the hygiene port provided at the galley because it provides hot water. The hose for the hygiene port is very long and can be extended to the WCS compartment for cleansing and grooming.

- The crew is provided with a no-rinse pouch assembly:
  - **No-Rinse body bath** and
  - **No-Rinse shampoo.**

  No-Rinse Body bath requires two ounces of cold water and six ounces of hot water to be added. This can last two days and be reheated if desired. Crew can squeeze the soapy water onto a washcloth to use for body cleansing.

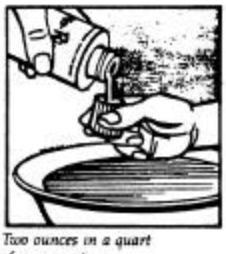
- Two washcloths and one towel per day are also provided to assist crewmembers in body cleansing. The washcloths are typical COTS items. Due to high linting of COTS towels, the towels are similar to dish towels -- not much nap but highly absorbent.

How No-Rinse® Body Bath Works

An alternate way to bathe

Here's a laboratory-controlled body wash product that cleans and refreshes without the need to use or transport rinse water. No rinsing is necessary since there is virtually no residue after use. Simply dilute two ounces in a quart of warm water. Apply the mildly foaming cleansing solution with a wash cloth. Then lightly towel dry. Gentle on sensitive skin.

No-Rinse Body Bath, originally formulated for hospital and convalescent care, eliminates the messiness of bar and liquid soaps and the inconvenience of rinsing. It is gaining in popularity because of its excellent results, ease of use and a substantial saving of time and manpower. Risk of transporting a patient to a tub or shower also is eliminated.



Two ounces in a quart of warm water.

Mildly foaming gentle solution cleans and refreshes.

A complete body bath in less than 10 minutes.

Contains No Alcohol

Satisfaction Guaranteed

How No-Rinse® Shampoo works

Penetrating foaming action does the cleaning

When applied and massaged, a rich lather causes dirt and dust particles to float to the top. The foam means the unique formula of No-Rinse Shampoo is doing its job. Then simply strip off excess lather and thoroughly towel dry the hair.

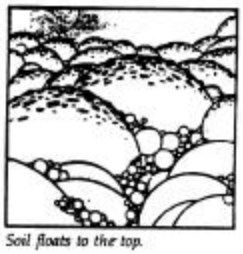
There is no alcohol in No-Rinse Shampoo to cause dryness. The hair is left sparkling clean, full-bodied and ready to comb and style.

The ingredients of No-Rinse, formulated scientifically in a laboratory atmosphere, produce a cleansing action that enhances the hair's beauty and manageability.

No-Rinse Shampoo can be used as often as you like. Absolutely no rinsing is required.

We have found, too, that many people use No-Rinse as a regular shampoo.

Foaming action goes to work.



Soil floats to the top.

Towel dry thoroughly, comb and style.

Biodegradable

pH Balanced

Figure 7.1a How No-Rinse Body Bath and No-Rinse Shampoo work

7.2 Other elements of Shuttle PHS

- A handwash station attached to the galley has been flown on early missions but is no longer provided.

- The WCS compartment has a door, privacy curtains, a PHS hose, a urine collector, stowage for WCS maintenance and toilet tissue, a detachable mirror, and the WCS, or toilet, itself.

- To the right of the toilet there is an operating handle and control panel to control the air flow. A vacuum venting system vents air and vapors and dries fecal waste and associated toilet paper.

- The urinal accommodates both males and females by use of a male or female designed attachable cap (caps are color coded by crewmember).

- To access the WCS, the door is opened and the privacy curtain can be drawn to afford privacy. Sufficient space is provided to permit changing of clothes as well.

- Detachable towel restraints (similar to Skylab) are located in the WCS to allow drying of towels and washcloths.

- The WCS requires periodic manual sanitation of the urinal and toilet seat and outlying areas with biocide and dry wipes.

- Personal hygiene items are packed in the Personal Hygiene Kit (PHK) to suit the personal requests for each crewmember. The PHK provides care for the skin, teeth, hair, face and nails.

  For skin care, lip balm and skin cream are provided.

  For dental care, toothbrush, toothpaste and dental floss per personal taste are provided.

  Hair care is supported by combs/brushes and No-Rinse Shampoo, a COTS medical supply product--no other brands are permitted. A hair care product intended specifically for African-American crewmembers is also provided on request.

  Face care provisions include shaving equipment for men and make-up for women. Men can select from either electric or safety razors. Shaving cream and styptic pencils are also available if requested. Women have a variety of make-up products they may select. If all, or a large number of make-up items are selected then the items are placed in the custom made make-up kit. Hair restraints (bands and barrettes) are included upon request. Nail care is limited to nail clippers.

- **Additional hygiene products** provided are:
  deodorant
  cotton swabs (Q-tips)
  Ziplock bags
  disposable gloves
  dry and wet wipes
  contact lens kit

8 SSF Zero-g Whole Body Shower

8.1 The Zero-g Shower Development Program

In 1985, the Man-System Division at the Johnson Space Center, in the wake of development of systems and subsystems for Space Station Freedom (SSF), initiated a program for the development of a Whole Body Shower (WBS) suitable for operation in a microgravity environment. Supporting this development effort was a systematic research program focused on **4 critical design aspects**:

- **human factors,**
- **biomedical,**
- **mechanical,**
- **electrical** and

on the **interfaces** between the whole body shower system and the other Space Station systems like -

- the water reclamation system and
- the air revitalization system.

A series of tests had been conducted to help define the design requirements for the Whole Body Shower. Crew interface research had helped identify major design parameters related to **enclosure configurations, consumable quantities, operation timelines, displays and controls, and shower and cleanup protocols**.

Mechanical research provided data on **relative humidity, air and water temperatures and flow rates, liquid and gas separation, and system efficiency**.

Electrical research helped characterize and quantify the **power requirements** for an optimized system.

Biomedical research not only provided data relevant to the identification and **control of micro-organisms introduced into the system** by human usage but also led to a new area of research—that of studying the **effects of biofilm within the shower system**.

8.2 The WBS test configuration

Structurally, the whole body shower system evaluated in this research was composed of a **shower stall** and the **hardware module**. **Figure 8.2a** depicts the mechanical configuration as well as the instrumentation test points within the shower system.

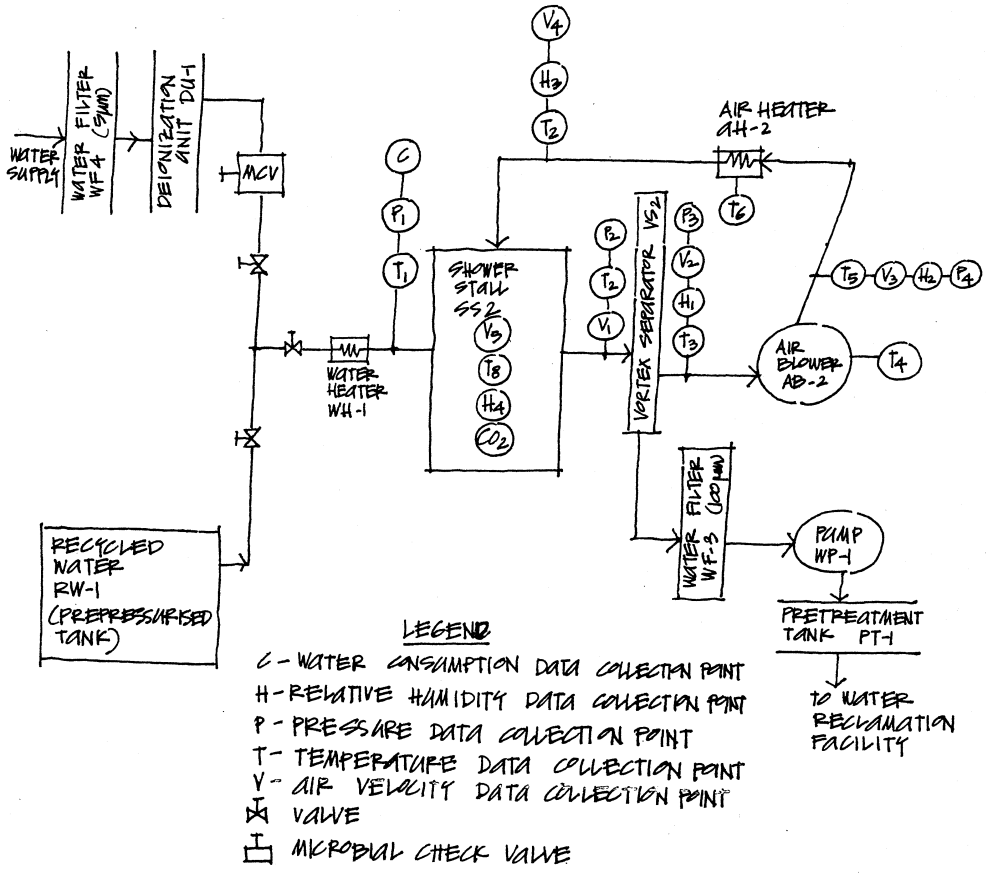


Figure 8.2a Mechanical configuration of the Whole Body Shower System

A fiberglass prototype for the **shower stall** (SS-2) was used for research and testing on the KC-135. A display and control panel in the shower stall provided the test subjects complete control of the showering process. The unit was also equipped with quick-disconnect fittings for the water and vacuum lines leading from the hardware module.

The **hardware module** contained the equipment required to operate the shower system. Components of the module included the ion-exchange unit (DU-1) with filter package for processing the regular tap water into a deionized state, as will be used on the Space Station; recycled water prepressurized tank (RW-1); water heater assembly (WH-1); air heater assembly (AH-2); air blower (AB-2); and vortex gas-liquid separator (VS-2). The whole body shower system was designed to utilize the power sources which would be available aboard Space Station Freedom (**28 Vdc and 120 Vac, 400 Hz**). Moreover, the design included all the necessary safeguards to protect the test subjects in the event of an emergency.

8.3 Scope of the Whole Body Shower Development Program

The research activities carried out in the first two phases of the Whole Body Shower Development Program consisted of tests and evaluations designed to collect data relevant to establishing the following:

- compatibility between the user and the shower equipment,
- selecting a cleansing agent for use in the shower system,
- understanding the micro-organism environment within the shower system and
- determining if the recycled shower wastewater processed by the water reclamation system could be safely used.

Human test subjects were used during the research in order for the investigators to evaluate the man-machine interaction process. Information on the personal responses and preferences of the users proved very beneficial in meeting the overall program goals.

A total of 14 test subjects (7 males and 7 females) participated in these evaluations. Each test subject showered in the WBS every 48 hours. The test subjects were provided wet wipe towelettes and baby wipes for unlimited use between showers, as needed for personal comfort and hygiene. During the showering process, the air pressure, temperature, and velocity, relative humidity, carbon dioxide build-up, water consumption and cleansing agent consumption were monitored and data collected every 2 minutes. Microbiological samples were taken from the shower wastewater and from the surface of the WBS system.

The **photographs** that follow vividly show the fiberglass prototype that was tested onboard the KC-135, the accessories like restraints etc., what happens to water in microgravity and close-up of the shower and suction heads.

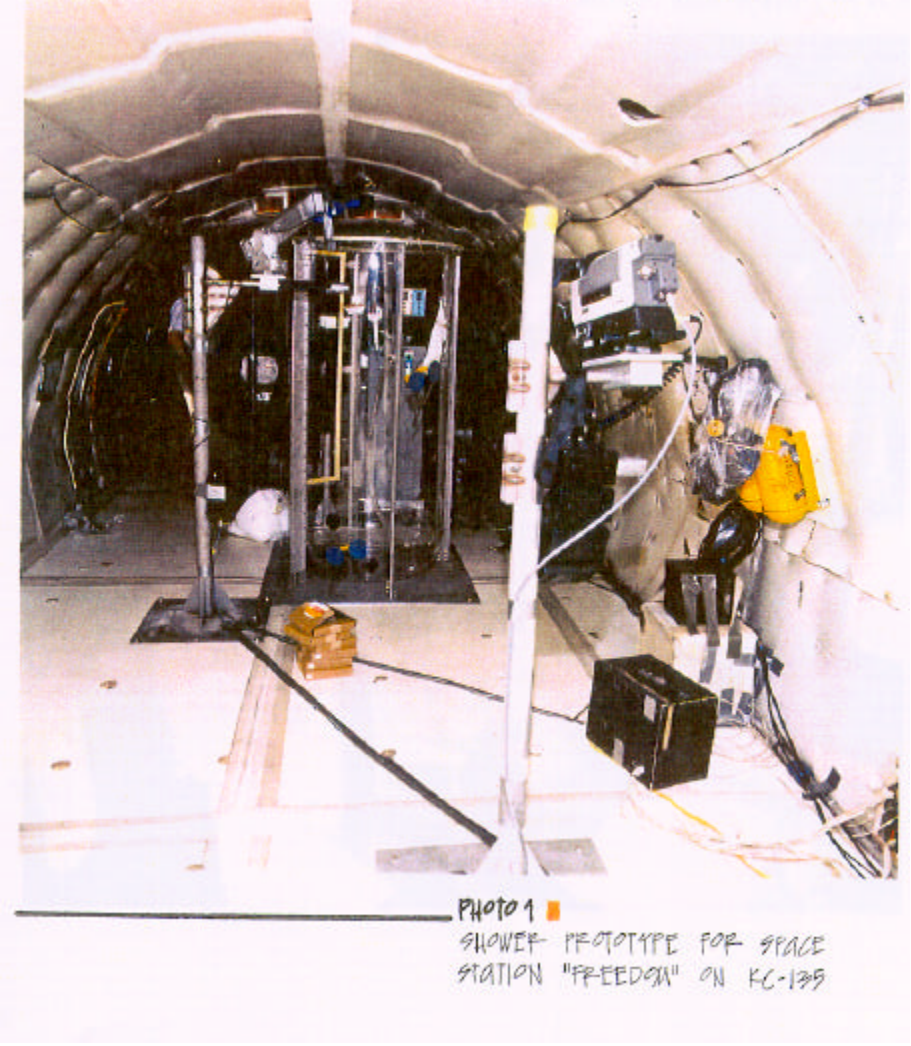


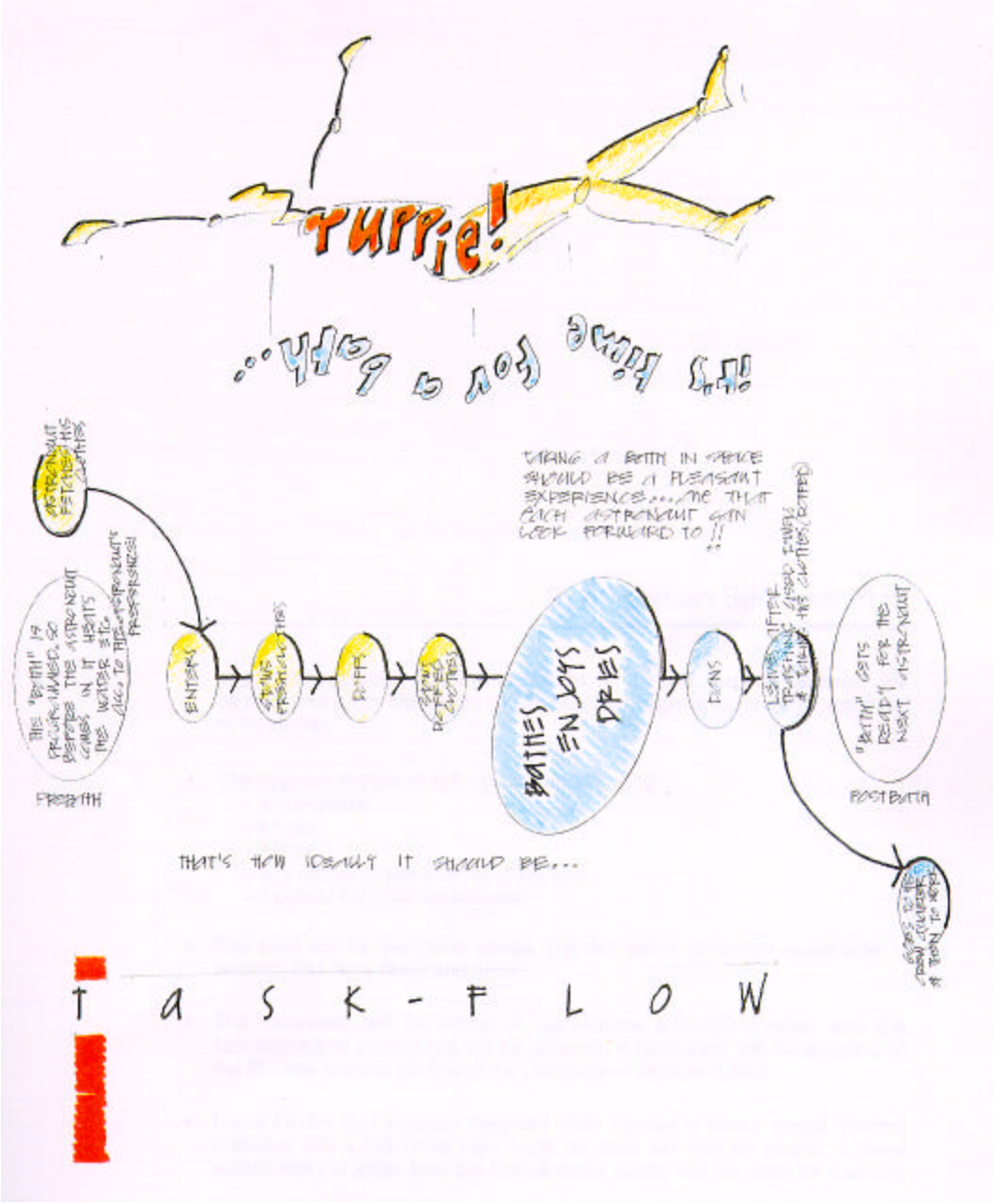
PHOTO 1
SHOWER PROTOTYPE FOR SPACE STATION "FREEDOM" ON KC-135

PHOTO 2
'FREEDOM' SHOWER PROTOTYPE BEING TESTED UNDER MICROGRAVITY ON KC-135

PHOTO 3
WATER, SOAP & GAS BEHAVE DIFFERENTLY IN ZERO-G

PHOTO 4
HANDHOLDS/FOOTRESTRAINTS ARE ESSENTIAL FOR SHOWERING IN SPACE

PHOTO 5
THE SHOWERING & SUCTION HEADS


TUPPIE!
it's time for a bath..
TASK-FLOW

9 ISS Alpha

9.1 Russian segment PHS

- In general, personal hygiene provisions for the ISS Russian Segment will be the same as for Mir. Items for the personal hygiene kit are also expected to be similar.

- The hygiene enclosure will include the following:
  - a handwash
  - a toilet
  - mirror
  - soft rubber straps and handrails and
  - a pocket for toilet accessories.

- The toilet will be the same except that the waste collection receptacle is smaller, less form fitting and fixed.

- The handwash will be similar in appearance although smaller, and the operations and procedures will be different. A handwash will be supplied in the Service Module (SM) and the Life Support Module (LSM).

- Plans for the ISS Russian Segment (RS) include a sauna styled thermal chamber with a cylindrical rigid body, air duct, fan and air heater. A towel wetted with hot water from the Rodnik water supply will be used for cleaning and steaming. Temperature settings for the air heater are 60, 70 and 80 degrees Celcius.

  Saunas will be permitted once per week with a 30 minute duration.

9.2 U.S. segment PHS

- The ISS U.S. Personal Hygiene Subsystem (PHS) provides:
  - facilities,
  - equipment,
  - supplies,
  - temporary stowage for personal cleansing and
  - contingency waste collection for urine and feces in the event of system failure up to 5 days.

- The PHS facilities consist of the Waste Management Compartment (WMC) and the Full Body Cleansing Compartment (FBCC).

- The **WMC** provides crewmember **privacy** and **restraint** for both liquid and solid waste collection. It comprises of:
  - a Commode Urinal Assembly (CUA).
  - a handwash unit and
  - stowage.

  The **CUA** collects, stabilizes and pretreats feces, emesis, menstrual waste and toilet paper.

  The **handwash** allows the following:
  - face, eye, hand and arm washing,
  - oral hygiene,
  - shaving and nail trimming.

  Hot and cold water can be mixed at the handwash to the desired temperature.

  Stowage is provided for tissues, toilet paper, wipes and cleansing agents. Cleansing agents are dispensed in either replaceable or refillable containers.

- The **FBCC** provides for crewmember showering in a closed compartment adjacent to the WMC. The shower allows crewmember control of water flow, air flow, and water temperature. The method for removing excess water from the body and the compartment is expected to be a suction wand for each crewmember. Restraints for stowage of wash cloths, brushes and cleansing agents are supplied.

- **Personal Hygiene Items** include:
  - Personal Hygiene Kit (PHK),
  - make-up kit,
  - feminine hygiene kit,
  - contact lens kit (if required),
  - body cleansing wipes (both wet and dry),
  - whole body cleansing agent,
  - tissues,
  - grooming aids (such as hair clippers)
  - hair dryer,
  - sleep eye-covers,
  - disposable ear protectors (for sleep).

For **personal waste management** the crew will be equipped with:
- toilet paper,
- emesis bags
- fecal bags,
- urine collection and absorption items like male and female funnels,
- respiratory filters and disposable gloves.

The contents of the PHK are still being defined, but are expected to be basically the same as for Shuttle, with the possible addition of mouthwash, if desired. PHK contents are COTS items selected by crew preference sufficient for a 90 day period.

- **Contingency urine/fecal collection** includes the Urine Collection Device (UCD) for males, the Maximum Absorption Garment (MAG) for females (and males if desired), and a contingency fecal bag.

10 Information Analysis

10.1 The Skylab shower drawbacks

- A 6 pound capacity water bottle was filled from the Waste Management Compartment (WMC) water heater for showering purposes. It took a **maximum of 45 minutes to heat 4 pounds of water from a cold start**.

  The water that came out of the heater was very hot—hotter than what one would want for a shower; but by the time the 6 pound capacity water bottle got filled up the water in the bottle was a bit too cool for a shower. So one of the astronauts wondered if the water temperature would have been just warm enough for a good shower if during each filling, they just filled up the bottle a little less full!

  When asked if 4 pounds of water would suffice for a complete shower, the astronauts were not too sure because they were already at a marginal **water quantity** anyway. One astronaut even wondered if one could get 4 pounds of hot water out of the heater and go in the food compartment and squirt the rest in from there to total up 6 pounds of pretty hot water! Then he remarked that, "I don't think it's going to be too hot for the astronaut wanting to take a shower because he can always wait a second till the water cooled off to the right temperature." Thus, **water-too-hot was not a problem, water-too-cold was surely a problem**.

- The **shower** aboard Skylab was considered a pleasant experience but was very **time** consuming, about **45 minutes** from start to finish.

- Sometimes using the **suction head** for drying oneself up after the shower did also become a little frustrating. So the astronauts would simply resort to **just wiping off the water because that was simpler and quicker!**

- Another observation that deserves a mention here, is that the astronaut never got as much water in the collection bag (as expected) as he squirted out of the water bottle probably because of the following reasons:
  - it would just evaporate,
  - most of it he got up with the towels and
  - a lot was on the body.

- **After washing and rinsing, water collection required for cleanup took 20 to 30 minutes**. *The cleanup was very time consuming and at times even frustrating. One of the Skylab astronauts who took the most showers* had a suggestion that to make showering simpler--just turn on the water and take a bath and whatever gets caught in the vacuum is great and whatever doesn't you just leave in there and blow the fan in there at night and evaporate!! In fact, for that mission, they blew the fan in there at night the times they used it and it got very dry and that meant that they had **less cleanup time which was desirable for everybody and yet probably didn't hurt the total system.**

- **Getting the water up off the sides of the shower with the suction head was a problem.** The shower vacuum wand suction was inadequate to handle the shower drying job required. Whatever the astronaut could not get with the suction head scrapper, he would have to mop up with a towel. Even the process itself was not very comfortable from an operational standpoint.

- **During the shower cleaning process, the astronaut would end up getting cold.** That was one of the reasons the shower was not used frequently. The problem was that when the astronaut was in there vacuuming himself and also vacuuming the shower, water drops that had come off him and that were on the side were then cold. So when he would back into it, it was like bumping into the cold sides of the shower.

- **Safety** was also a **concern**. One of the astronauts was reported saying during a crew debrief that, "One thing, I noticed in taking a shower was that at first I tended to use the water sparingly because there wasn't too much to begin with and after a while you said to heck with it. I'm just going to use it so I sprayed it all over and several bursts like that and I did inhale it. So I think if you did get too much **water floating around** like that because of the fine spray it did create kind of a mispattern in the volume of the shower and it was **objectionable to inhale it.**"

- It has also been reported that **water droplets floating around also sometimes stick together to form water blobs** which have an **affinity for body sockets like the eyes, ears, nose etc.** Even that can be very dangerous. For example, if a big blob of water got into an eye socket it would be **pretty difficult to wipe it off** because water in zero-g adheres very well to the skin and is not so simple to wipe off.

- Besides, even the **Miranol soap** that was being used with the shower was **highly concentrated**. The astronauts using it for the shower complained that it would **stay on** them and **stink** for a couple of days after one took a shower whenever he got warmed up, worked on the bike or anything like that. In other words, the odor and feel after showering were considered undesirable. Toward the end of the third manned period, the liquid soap was depleted and a **bar soap** was substituted. This

may have contributed to the **blower failure**, as the bar soap would quickly break down the hydrophobic filter and, in time, clog the separator.

- There were also some comments from the users onboard about the **shower curtain feeling cold when touched**.

- Another thing that the shower had against it was that it was so dry in the Skylab workshop that the astronauts did not sweat much. The only thing that made them really sweat was the resistance exercise. **It was so clean out there that they didn't need a shower much!**

- On day 263, the crew reported that the blower was inoperative, probably the result of water passing through the filter into the blower, and the shower was not used again.

10.2 The drawbacks of the Mir shower

- The **time consumed for one shower ritual** aboard Mir can be averaged as following:

Heating the water for a shower that lasted 3 to 4 minutes	40 minutes
Taking a complete shower	05 minutes
Drying and dressing	15 minutes
Drying off the shower with towels	20 minutes
Disinfecting the shower	02 hours
Total time required	**3 hours and 20 minutes**

- There was **no water suction wand to remove excess water, so toweling was the only method for removing water that clung to the shower enclosure and the crewmember**. A layer of water, typically dirty water, sometimes built up on the body, as well as the shower walls causing some **discomfort** and a **lack of cleanliness** during a shower. An outside air breathing hose could be used if desired, but was not necessary.

- Showering was not performed very often because of **water leakage and the difficulty and time necessary for cleaning and water collection**.

10.3 Astronaut debriefs—inferences drawn

The American long-duration stay experiences onboard the Skylab and onboard Mir and also the Russian inputs give valuable insight to the designers, engineers and human factors specialists about the critical factors that should be kept in mind while designing products and product systems for ISS-Alpha.

The inferences drawn from the debriefs of the Skylab and Mir astronauts can be summarized as follows:

- The **biggest drawback** of having a **shower** onboard is the **operational overhead** that goes with it. After showering and rinsing, cleaning up the shower takes about 30 minutes. If an astronaut has to spend such a lot of time for cleaning up a shower after using it, that would deter him from using the shower.

- **Two out of the three American astronauts who have been onboard Mir feel that a shower is not necessary for a 90-day stay in Space (i.e. onboard ISS-Alpha);** we should watch out for the responses of the future American astronauts who are/will be staying on Mir for long durations.

- **One out of the three** above mentioned astronauts said that a **shower** would be **desirable only if** it had a **low operational overhead.**

- One needs to **break away from "Earth paradigms"** because living and working in a weightless environment is very different and **what's good on Earth is not necessarily good in Space**; on the contrary, one needs to look at the lifestyles of the astronauts and cosmonauts and learn from their experiences.

- Each of the **astronauts adapted** very well to the zero-g environment very well as far as personal hygiene was concerned; and like John Blaha said, **once you are out there, you "learn" how to do it by doing it and improvising till you like it.**

- The **Russian pre-wetted towels** were something that each of the **3 American astronauts liked very much**; in fact they all found it to be **superior to** what they have on the Shuttle i.e. **wetting a dry towel by squirting water on it**.

- However, one needs to deal with the following facts that the prewetted towels once dried were not reusable and that one cannot simply leave them out to dry because there were some volatiles in them that adversely affect the atmospheric regeneration system.

- There were no complaints from the astronauts regarding the shampoo and the soap; so one can continue to use the same for ISS-Alpha; **it would also be a good idea to try to come up with some "herbal soap and shampoo" that will work as good as or perhaps even better than the chemical based cleansers**; some Shuttle astronauts have reported the need to use the shampoo twice to get their hair to feel as clean as they do on Earth.

- Shannon Lucid, when asked if having a **laundry** onboard the ISS is a good idea, said that it would actually be a bother—it's better not to; Norman Thagard proposed that the Russian system of giving 1 wet and 2 dry towels a day need to be changed to **2 wet and 2 dry towels per day keeping in mind the fact that there are 2 exercise sessions per day.**

- The sauna is more of a cultural issue while the personal hygiene kit is more of a personal preference issue.

- The Russians think a shower is not a good idea for ISS.

- It would be a good idea **not to have identical hygiene stuff on both the sides i.e. the Russian and the American because all astronauts and cosmonauts, as is true with human nature, look for a change once in a while¾ so by not having identical soap, shampoo etc. one can get the Russians to come over to the American side for a bath once in a while and vice versa.**

- Shannon Lucid reported that during her mission they ran out of dry towels and when Progress came they had more wet towels, but no dry towels; so we should have a **system that eliminates the possibility of running out of dry or wet towels** at any point of time during the mission.

- Norman Thagard said that when he left for Mir he was told that there was already some soapless shampoo onboard, but he never found it; since **stowage is a problem, the system that we go in for on the ISS should facilitate the need to store soap/shampoo outside of the system.**

- John Blaha had a good suggestion regarding the pre-wetted towels; he said that some people don't like to use them at ambient temperature which for them is "cool/cold" so there should be a provision to warm the prewetted towels.

- Shannon Lucid said that the current Russian system of whole body cleansing for long-duration missions **"was totally adequate and made one feel nice and fresh"**; Norman Thagard said that we ought to look into the **Russian system of personal hygiene because he found it to be a good one and that we ought to consider supplementing it so that the astronauts get two of the wetted towels a day instead of just one; John Blaha said that the bath that he took using the Russian system complimented with the American shampoo/bodybath and drink bags made him feel very clean and it felt like a real shower.**

10.4 Task flow

- **The following pages (photos 6 to 15) give a vivid picture of what the task flow must be like when a shower is used under microgravity conditions**. The photos are from the fiberglass shower prototype (designed for SSF) testing on the KC-135. Following the series of photographs is a panel showing what would be the **"ideal task flow"** for full body cleansing on ISS-Alpha. This is the task flow that one should aim for while designing a whole body cleansing system for the astronauts onboard the U.S. Hab module in ISS-Alpha.

PHOTO 6
DONNING & DOFFING INSIDE A SHOWER ENCLOSURE IN ZERO-G ISN'T SIMPLE!

PHOTO 7
SQUIRTING WATER ONTO A WASHCLOTH USING THE SHOWER HEAD

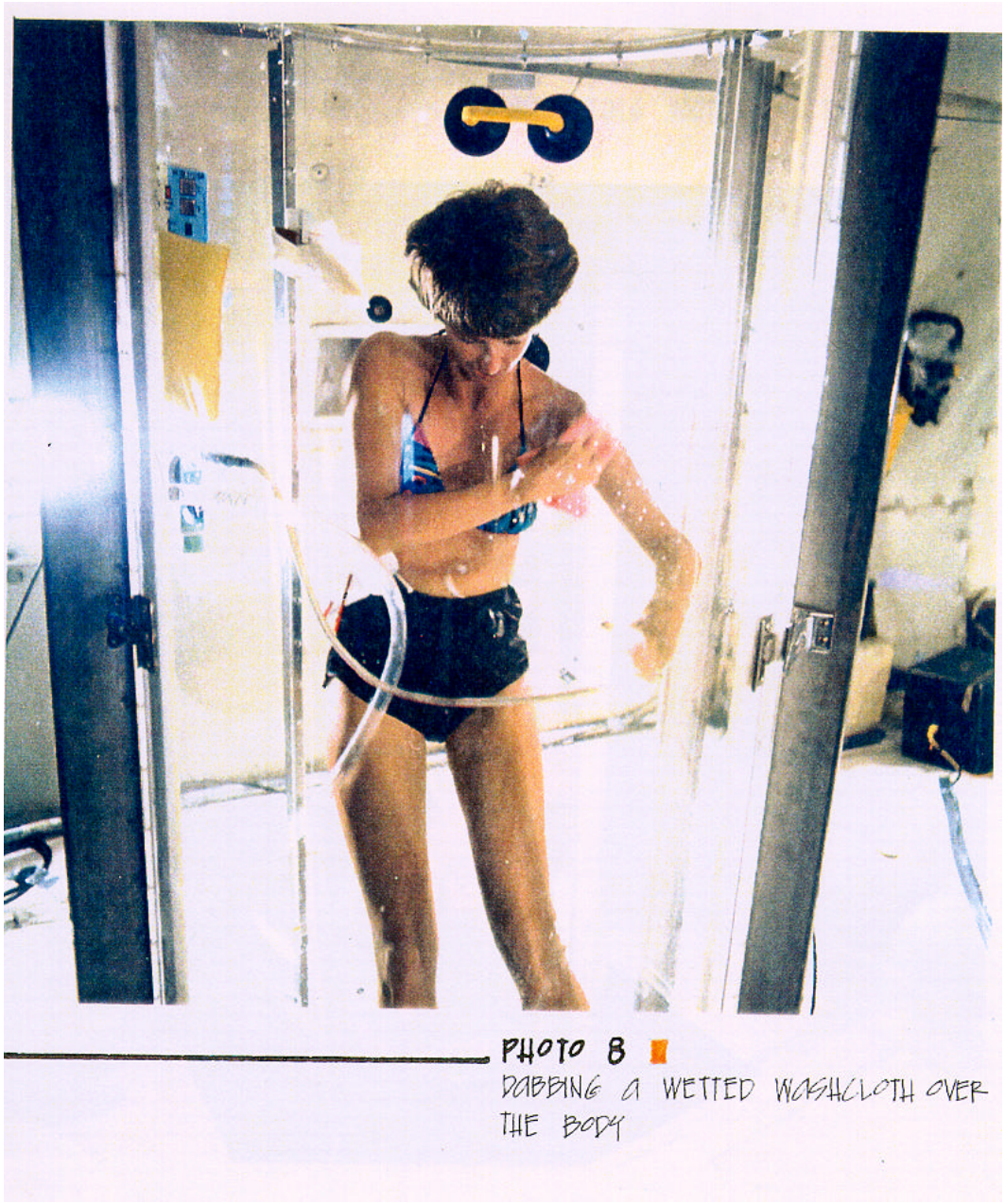


PHOTO 8
DABBING A WETTED WASHCLOTH OVER THE BODY

PHOTO 9
SQUIRTING WATER ON THE BODY

PHOTO 10
SQUIRTING WATER ONTO THE TOWEL BEFORE ...


PHOTO 11
... APPLYING LIQUID SOAP TO IT

PHOTO 12
AFTER SHOWERING IS COMPLETE THE SUCTION HEAD IS USED FOR VACUUMING

PHOTO 13
AFTER BATH THE BODY CAN BE DRIED BY VACUUMING IT ... OR ...

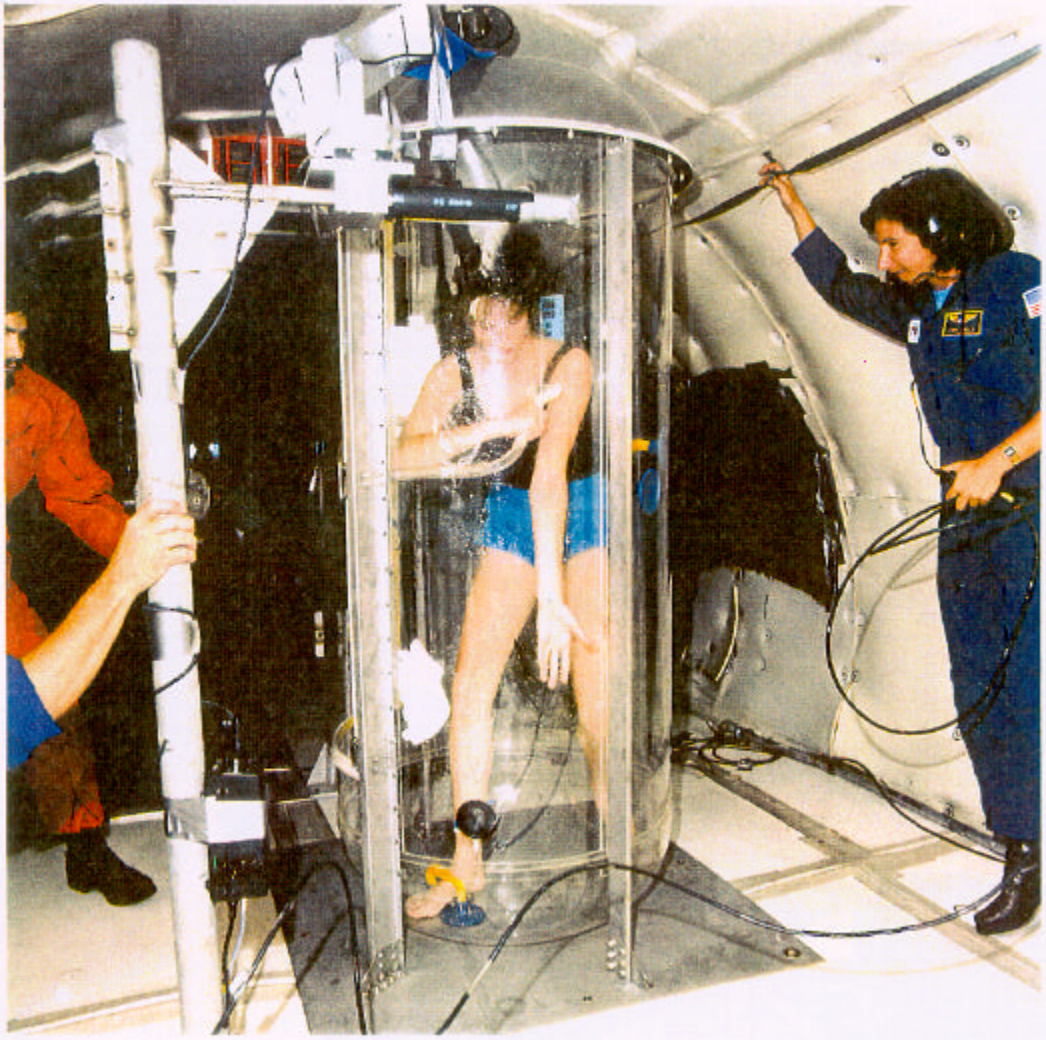


PHOTO 14
DRYING OFF WITH A TOWEL IS EASIER & FASTER

PHOTO 15
CLEANING/DRYING UP THE SHOWER AFTER BATH BY VACUUMING OR USING A TOWEL

11 Redefined Brief

11.1 Redefined design brief

The initial brief has been refined and elaborated from a set of broad objectives into a more detailed list of product, user and environmental requirements. And this has been done keeping in mind the data collected anyalyzed from

- the whole body cleansing methods used on Space stations/freighters so far,
- the Skylab and Mir crew debriefs and
- the extensive experimental research carried out on a Whole Body Shower designed for Space Station Freedom.

Evolve design concepts for Zero-g Whole Body Cleansing onboard the U.S. Habitation Module of the International Space Station (ISS) Alpha and elaborate the chosen concept to a preliminary level which will serve as a vantage point from where it can be taken further and detailed out for prototype making and testing.

- It should cater to the **international crew** onboard ISS.
- It should be **compatible** with **the "ideal task flow"** diagram shown in section 10.4; only then can one be sure that the astronauts will use it.
- It should take into account a **duration** of **90 days** onboard ISS.

In size and configuration, it should be **compatible** with the **rack dimensions** of the U.S. Hab Module of ISS so that it's convenient to transport to/install in Space.

It should be **easy to use, clean, maintain** and **repair** in Space.

It should be **compact, light** and compatible with **power** consumption requirements onboard.

It should be **in tune** with the **astronaut feedback** that we have so far received from the astronauts of long-duration missions.

It should be **reliable, user-friendly** and **safe**.

It should make the astronaut feel **clean**, **fresh** and **warm**; in other words it should satisfy the physiological and psychological requirements of the users.

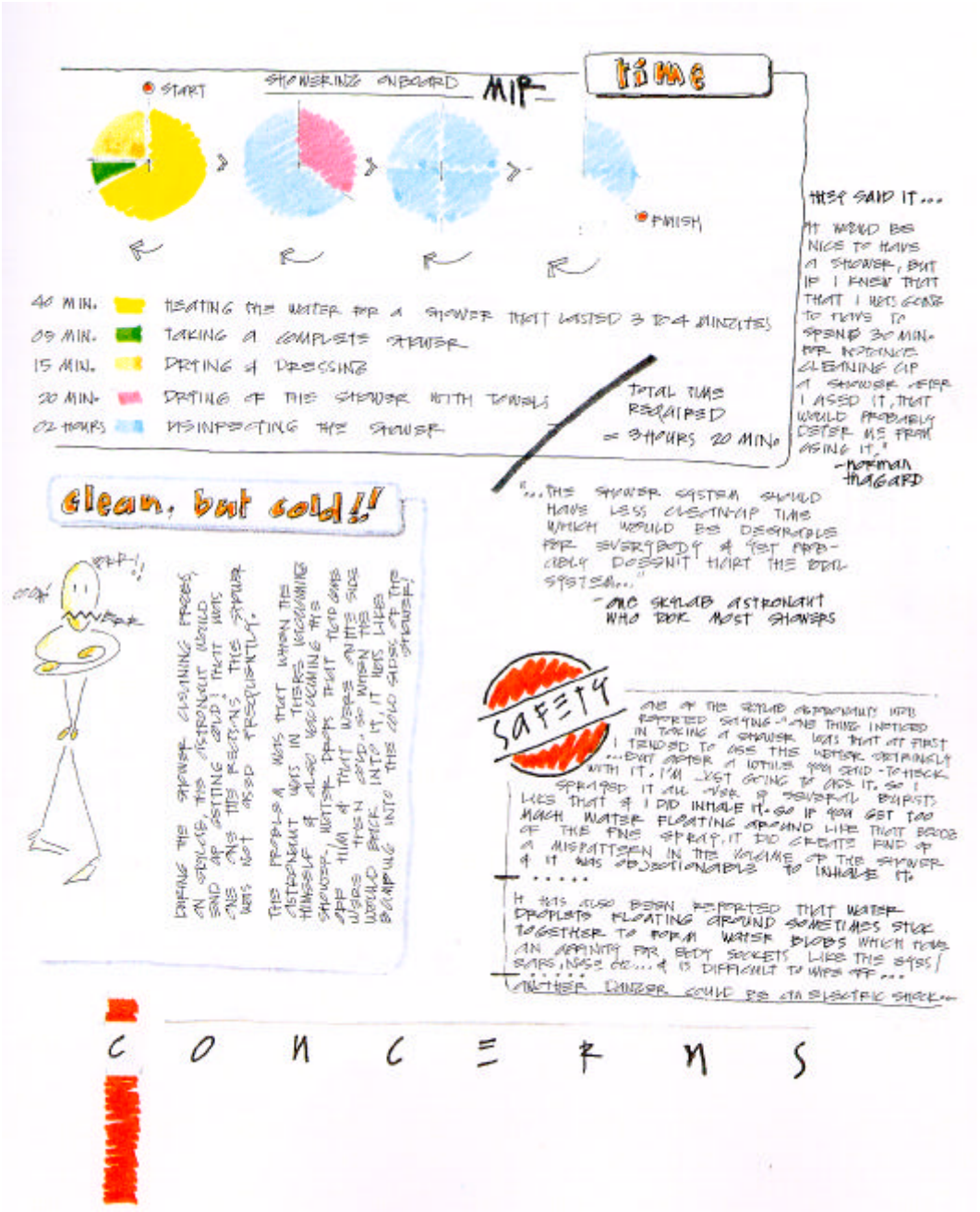
It should allow the astronaut to take a bath wherever he wishes and does not force him to perform the full body cleansing function inside a dedicated enclosure; in other words, it should be a **flexible** system.

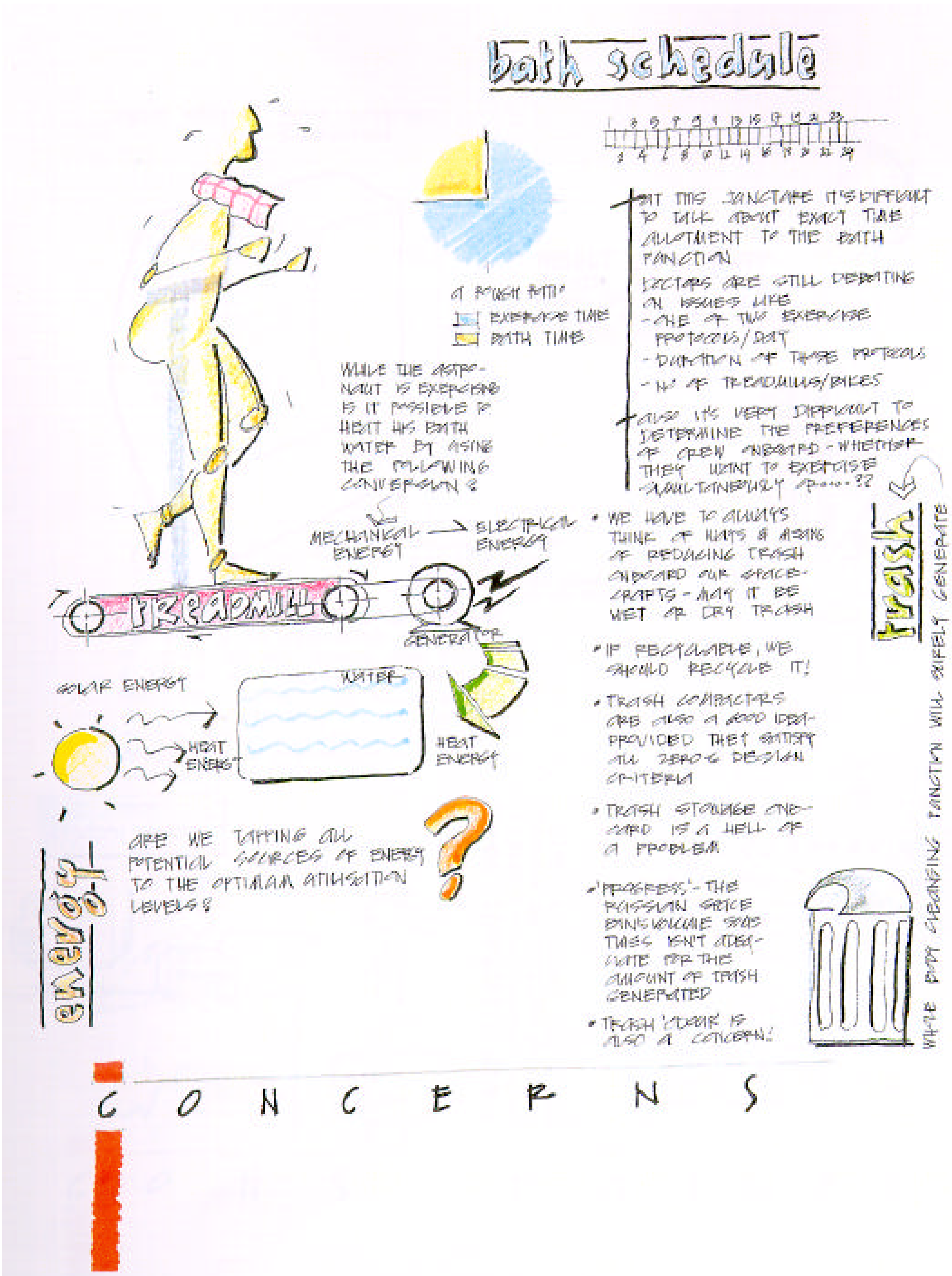
It should be an **elegant design solution**.

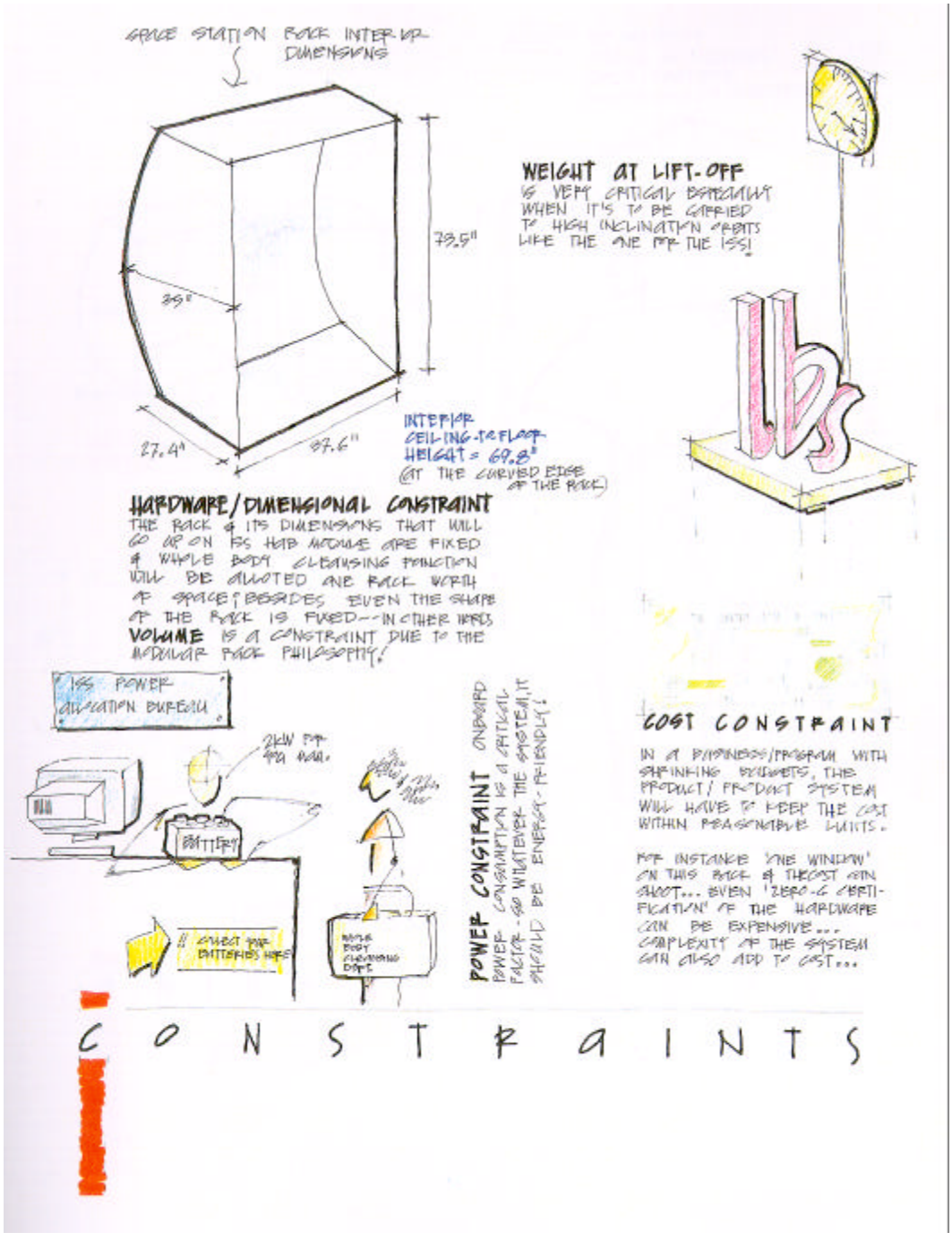
It should **not** be **time consuming**. The operational overhead should be negligible.

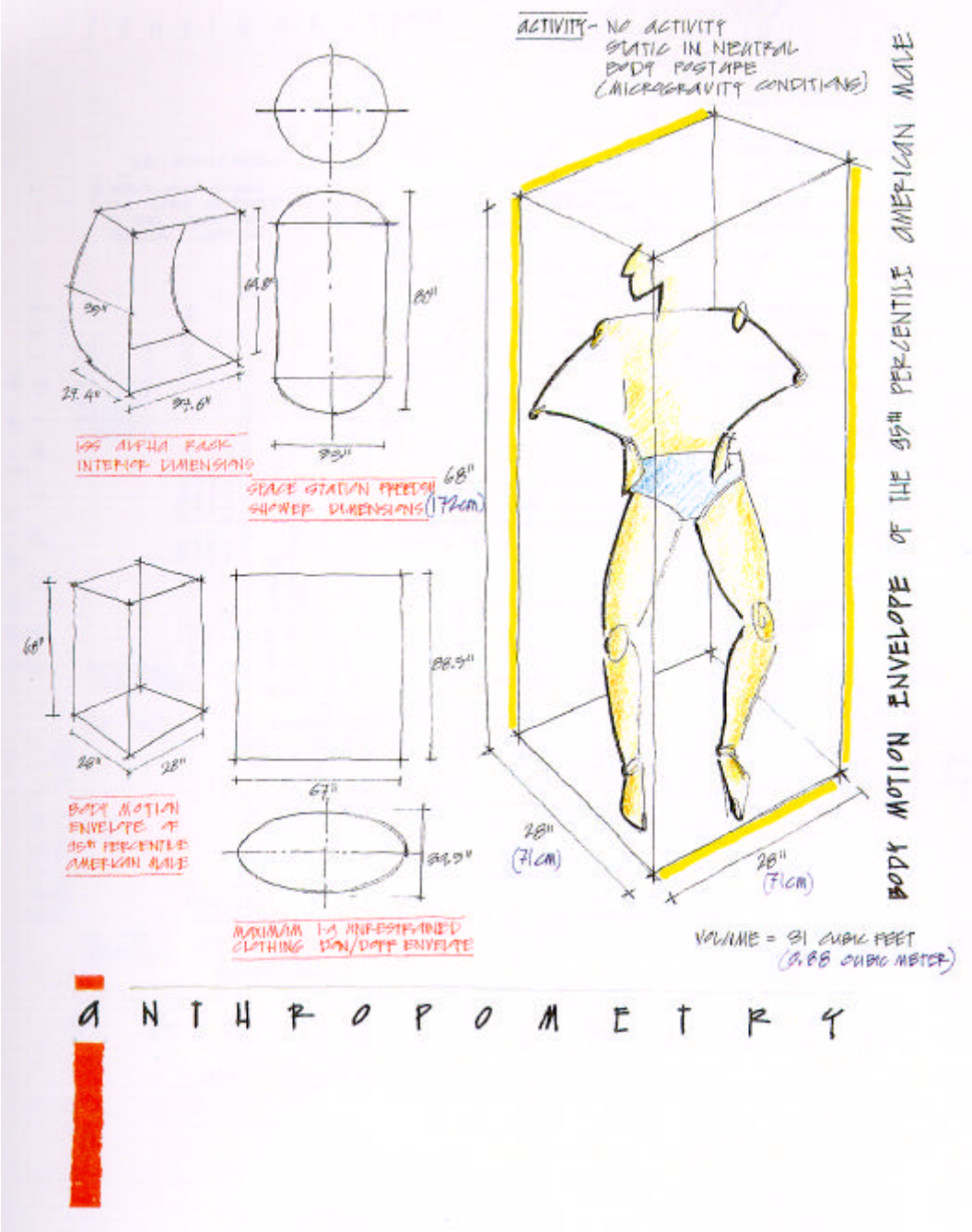
11.2 Design concerns and constraints

The following pages will graphically show the prime design concerns and constraints and will also take a look at the anthropometric considerations involved.

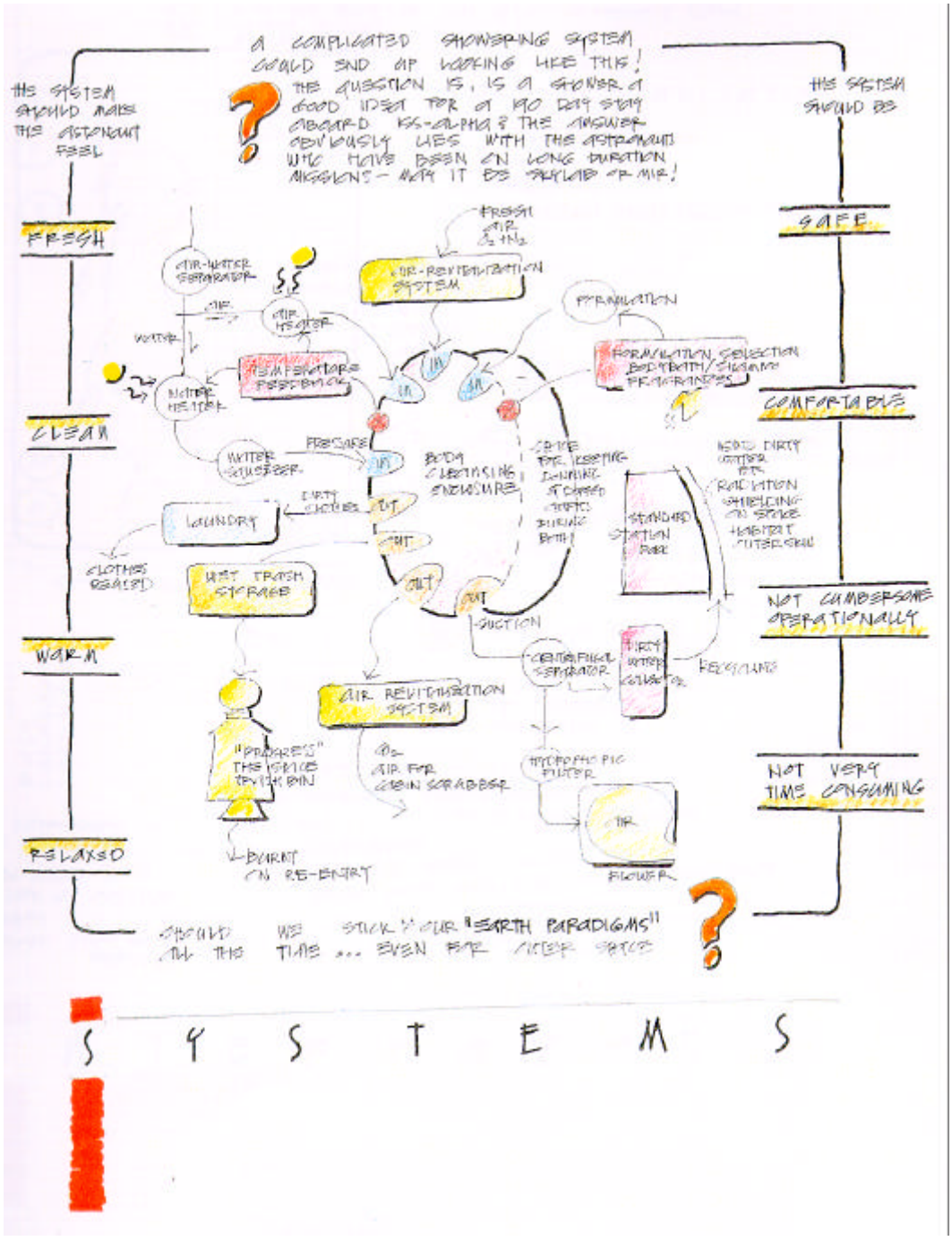

time
START
SHOWERING ONBOARD MIR
FINISH
40 MIN. HEATING THE WATER FOR A SHOWER THAT LASTED 3 TO 4 MINUTES
09 MIN. TAKING A COMPLETE SHOWER
15 MIN. DRYING & DRESSING
20 MIN. DRYING OF THE SHOWER WITH TOWELS
02 HOURS DISINFECTING THE SHOWER
TOTAL TIME REQUIRED = 3 HOURS 20 MIN.
THEY SAID IT...
"IT WOULD BE NICE TO HAVE A SHOWER, BUT IF I KNEW THAT THAT I WAS GOING TO HAVE TO SPEND 3½ MIN. PER INCIDENCE CLEANING UP A SHOWER AFTER I USED IT, THAT WOULD PROBABLY DETER ME FROM USING IT."
-NORMAN THAGARD
"...THE SHOWER SYSTEM SHOULD HAVE LESS CLEAN-UP TIME WHICH WOULD BE DESIRABLE FOR EVERYBODY & YET PROBABLY DOESN'T HURT THE BODY SYSTEM..."
-ONE SKYLAB ASTRONAUT WHO TOOK MOST SHOWERS
clean, but cold!!
SAFETY
CONCERNS

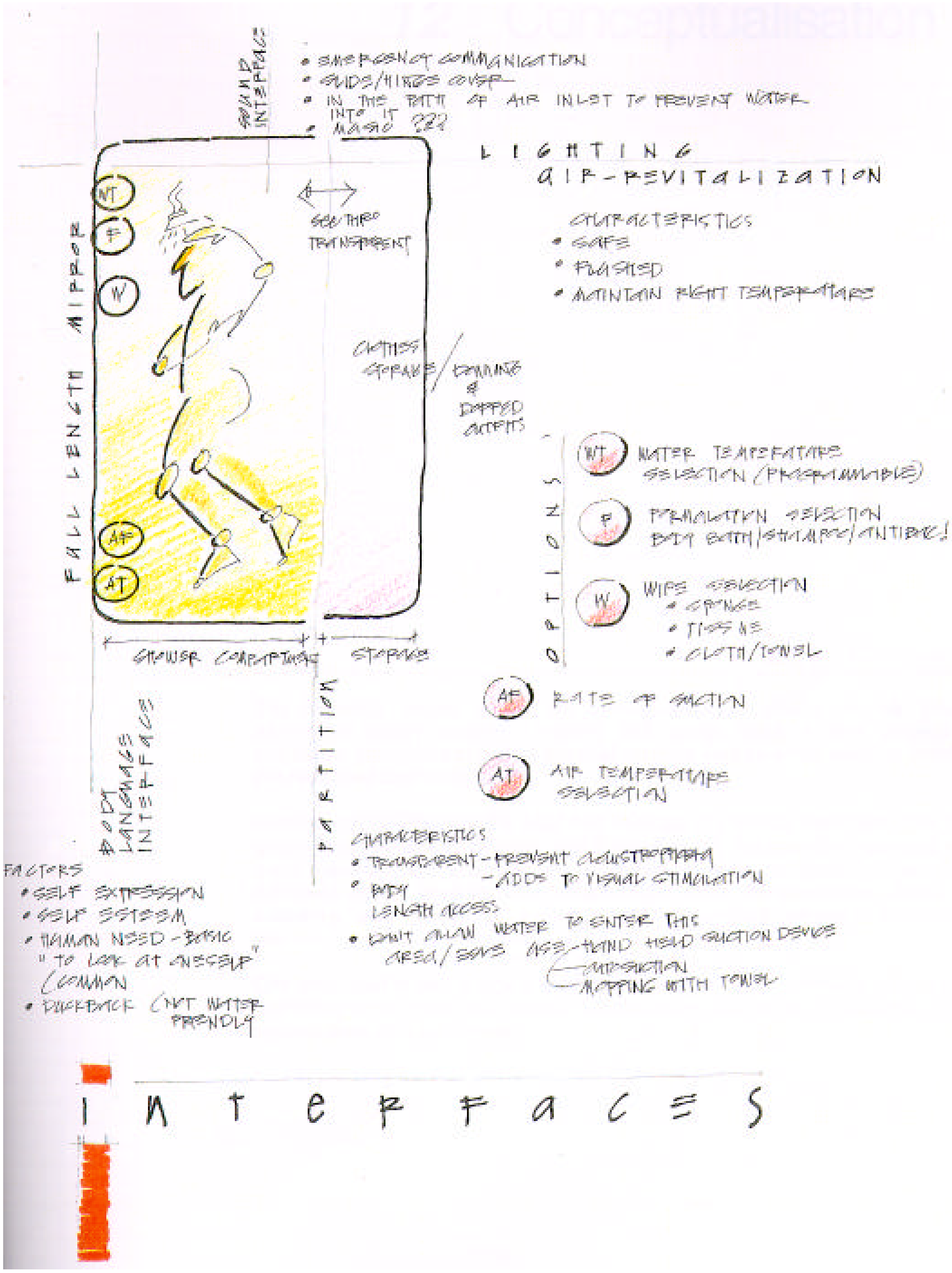

bath schedule
A ROUGH RATIO
EXERCISE TIME
BATH TIME
AT THIS JUNCTURE IT'S DIFFICULT TO TALK ABOUT EXACT TIME ALLOTMENT TO THE BATH FUNCTION
DOCTORS ARE STILL DEBATING ON ISSUES LIKE
- ONE OR TWO EXERCISE PROTOCOLS / DAY
- DURATION OF THESE PROTOCOLS
- NO OF TREADMILLS/BIKES
ALSO IT'S VERY DIFFICULT TO DETERMINE THE PREFERENCES OF CREW ONBOARD - WHETHER THEY WANT TO EXERCISE SIMULTANEOUSLY or ....??
WHILE THE ASTRONAUT IS EXERCISING IS IT POSSIBLE TO HEAT HIS BATH WATER BY USING THE FOLLOWING CONVERSION ?
MECHANICAL ENERGY
ELECTRICAL ENERGY
TREADMILL
GENERATOR
SOLAR ENERGY
WATER
HEAT ENERGY
HEAT ENERGY
ARE WE TAPPING ALL POTENTIAL SOURCES OF ENERGY TO THE OPTIMUM UTILISATION LEVELS ?
energy
• WE HAVE TO ALWAYS THINK OF WAYS & MEANS OF REDUCING TRASH ONBOARD OUR SPACECRAFTS - MAY IT BE WET OR DRY TRASH
• IF RECYCLABLE, WE SHOULD RECYCLE IT!
• TRASH COMPACTORS ARE ALSO A GOOD IDEA - PROVIDED THEY SATISFY ALL ZERO-G DESIGN CRITERIA
• TRASH STORAGE ONBOARD IS A HELL OF A PROBLEM
• 'PROGRESS' - THE RUSSIAN SPACE BIN'S VOLUME SAYS THIS ISN'T ADEQUATE FOR THE AMOUNT OF TRASH GENERATED
• TRASH ODOUR IS ALSO A CONCERN!
trash
WHOLE BODY CLEANSING FUNCTION WILL SURELY GENERATE
CONCERNS


SPACE STATION RACK INTERFACE DIMENSIONS
79.5"
29"
27.4"
97.6"
INTERIOR CEILING-TO-FLOOR HEIGHT = 69.8" (AT THE CURVED EDGE OF THE RACK)
WEIGHT AT LIFT-OFF
IS VERY CRITICAL ESPECIALLY WHEN IT'S TO BE CARRIED TO HIGH INCLINATION ORBITS LIKE THE ONE FOR THE ISS!
lbs
HARDWARE/DIMENSIONAL CONSTRAINT
THE RACK & ITS DIMENSIONS THAT WILL GO UP ON ISS HAB MODULE ARE FIXED & WHOLE BODY CLEANSING FUNCTION WILL BE ALLOTED ONE RACK WORTH OF SPACE! BESIDES EVEN THE SHAPE OF THE RACK IS FIXED--IN OTHER WORDS VOLUME IS A CONSTRAINT DUE TO THE MODULAR RACK PHILOSOPHY!
ISS POWER ALLOCATION BUREAU
2KW FOR WBC.
BATTERY
POWER CONSTRAINT ONBOARD POWER CONSUMPTION IS A CRITICAL FACTOR - SO WHATEVER THE SYSTEM, IT SHOULD BE ENERGY-FRIENDLY!
COST CONSTRAINT
IN A BUSINESS/PROGRAM WITH SHRINKING BUDGETS, THE PRODUCT/PRODUCT SYSTEM WILL HAVE TO KEEP THE COST WITHIN REASONABLE LIMITS.
FOR INSTANCE 'ONE WINDOW' ON THIS RACK OF THE COST CAN SHOOT... EVEN 'ZERO-G CERTIFICATION' OF THE HARDWARE CAN BE EXPENSIVE... COMPLEXITY OF THE SYSTEM CAN ALSO ADD TO COST...
CONSTRAINTS


ACTIVITY- NO ACTIVITY
STATIC IN NEUTRAL
BODY POSTAPE
(MICROGRAVITY CONDITIONS)
BODY MOTION ENVELOPE OF THE 95TH PERCENTILE AMERICAN MALE
ANTHROPOMETRY
LSS ALPHA PACK
INTERIOR DIMENSIONS
SPACE STATION FREEDOM
SHOWER DIMENSIONS
68"
(172cm)
BODY MOTION
ENVELOPE OF
95TH PERCENTILE
AMERICAN MALE
MAXIMUM I-G UNRESTRAINED
CLOTHING SKIN/DOFF ENVELOPE
28"
(71cm)
28"
(71cm)
VOLUME = 31 CUBIC FEET
(0.88 CUBIC METER)


C·O·N·F·I·G·U·R·A·T·I·O·N·
RESTRAINTS
NO PROTRUSIONS
NO SHARP CORNERS
CORDLESS
LOCATION FLEXIBILITY
THE WALL
Mental Losses
Frequency of baths
Mobility
Privacy
Mixed crews
Cultural differences
BRAINSTORMING


A COMPLICATED SHOWERING SYSTEM COULD END UP WORKING LIKE THIS!
THE QUESTION IS, IS A SHOWER A GOOD IDEA FOR A 90 DAY STAY ABOARD ISS-ALPHA? THE ANSWER OBVIOUSLY LIES WITH THE ASTRONAUTS WHO HAVE BEEN ON LONG DURATION MISSIONS - MAY IT BE SKYLAB OR MIR!
THIS SYSTEM SHOULD MAKE THE ASTRONAUT FEEL
THIS SYSTEM SHOULD BE
FRESH
CLEAN
WARM
RELAXED
SAFE
COMFORTABLE
NOT CUMBERSOME OPERATIONALLY
NOT VERY TIME CONSUMING
AIR-WATER SEPARATOR
AIR HEATER
WATER HEATER
AIR-REVITALIZATION SYSTEM
FORMULATION
FORMULATION, SELECTION BODY BATH/SHAMPOO FRAGRANCES
WATER DISPENSER
LAUNDRY
CLOTHES DRIED
WET TRASH STORAGE
BODY CLEANSING ENCLOSURE
STANDARD STATION FARE
RADIATION SHIELDING ON SPACE HABITAT OUTER SKIN
SUCTION
CENTRIFUGAL SEPARATOR
RECYCLING
"PROGRESS" THE VORTEX TRASH BIN
AIR FOR CABIN SCRUBBER
HYDROPHOBIC FILTER
BLOWER
BURNT ON RE-ENTRY
SHOULD WE STICK TO OUR "EARTH PARADIGMS" ALL THE TIME ... EVEN FOR OUTER SPACE?
S Y S T E M S


• EMERGENCY COMMUNICATION
• SLIDES/HINGES COVER
• IN THE PATH OF AIR INLET TO PREVENT WATER INTO IT
• MAGIC ???
SOUND INTERFACE
LIGHTING
AIR-REVITALIZATION
CHARACTERISTICS
• SAFE
• FLUSHED
• MAINTAIN RIGHT TEMPERATURE
SEE THRO TRANSPARENT
CLOTHES STORAGE
FULL LENGTH MIRROR
WT
F
W
AF
AT
OPTIONS
WT WATER TEMPERATURE SELECTION (PROGRAMMABLE)
F FORMULATION SELECTION BODY BATH/SHAMPOO/ANTIBAC!
W WIPES SELECTION
• SPONGE
• TISSUES
• CLOTH/TOWEL
AF RATE OF SUCTION
AT AIR TEMPERATURE SELECTION
SHOWER COMPARTMENT
STORAGE
PARTITION
BODY LANGUAGE INTERFACE
CHARACTERISTICS
• TRANSPARENT - PREVENT CLAUSTROPHOBIA
- ADDS TO VISUAL STIMULATION
• BODY LENGTH ACCESS
• DON'T ALLOW WATER TO ENTER THIS AREA
HAND HELD SUCTION DEVICE
MOPPING WITH TOWEL
FACTORS
• SELF EXPRESSION
• SELF ESTEEM
• HUMAN NEED - BASIC "TO LOOK AT ONESELF"
• DRAWBACK (NOT WATER FRIENDLY)
INTERFACES

12 Conceptualization

12.1 Concepts

The following pages record the conceptualization phase. In this phase alternative design solution principles and design variants were generated, evaluated, eliminated and then the final concept was selected keeping in mind the redefined brief criteria.

Several possibilities like the snail bag concept, the hausel dispenser idea, the shower with automatic cleaning and flushed urinal, the bean bath concept etc. were explored and analyzed on the basis of a set of design criteria like astronaut **(user) preferences, aesthetics, ease of operation, ease of cleaning and repairing, anthropometric comfort, privacy, and flexibility.**

One even tried to take a look at the "in" and "out" points of a shower system and found that to be pretty complicated; Interfaces as well as the intelligence of the system were also considered.

13 The Final Concept

13.1 The final concept

The final concept that was chosen has been shown graphically in this section of the document. The salient features of the final concept are as follows:

- It proposes the use of **one dedicated rack** for the function of whole body cleansing keeping in mind that **privacy** is desirable in the case of mixed crew composition and also to cater to **cultural variants** since the crew onboard ISS will be an international crew; it will have a **sliding privacy curtain** which may or may not be used during any cleansing process.

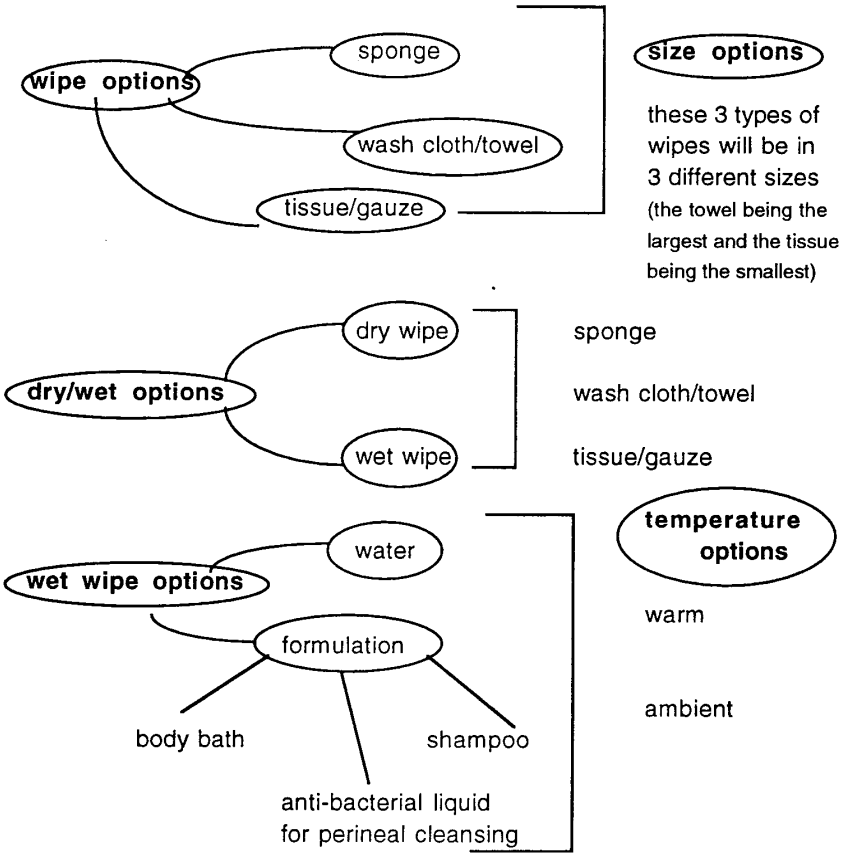
- However, it **does not restrict the whole body cleansing function to be performed only within the dedicated space**; thanks to the hausel dispenser idea, an **astronaut/cosmonaut can also choose to go over to any other part of the station,** e.g. his/her crew quarter, for the whole body cleansing task.

- The hausel dispenser will incorporate **hot and cold water needle dispensers which will be compatible with the Shuttle drink bags**; each astronaut should be provided with a quota of these **drink bags sized appropriately as bath bags** for the whole duration of the flight as a part of his personal hygiene kit package.

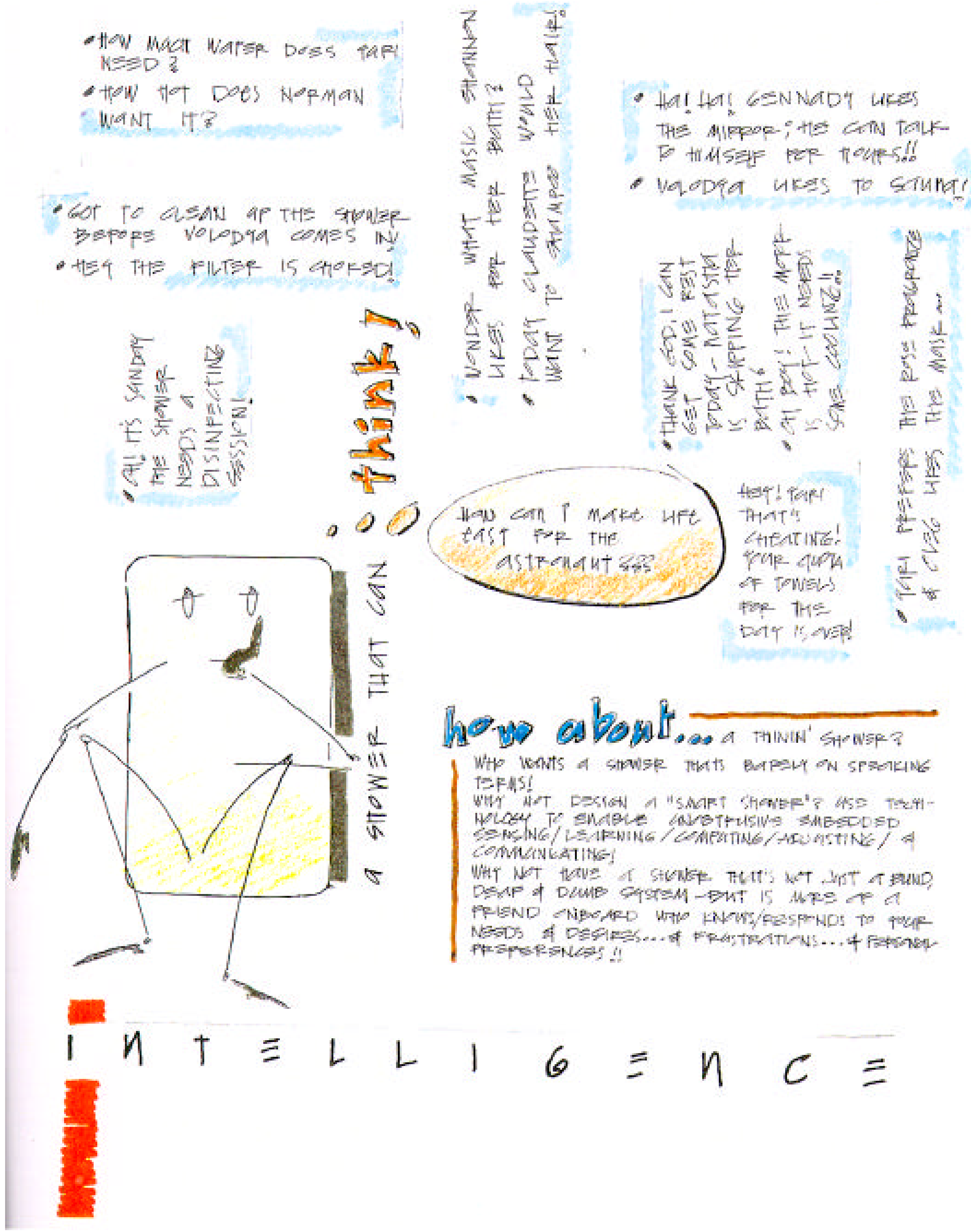
- The **hausel dispenser** will be **flushed** into the curve of the rack so as not to hurt or interfere with the task being performed inside the rack enclosure; it will also incorporate a depression on the top which will be built into the cover of the dispenser and which will serve as a **hand hold**.

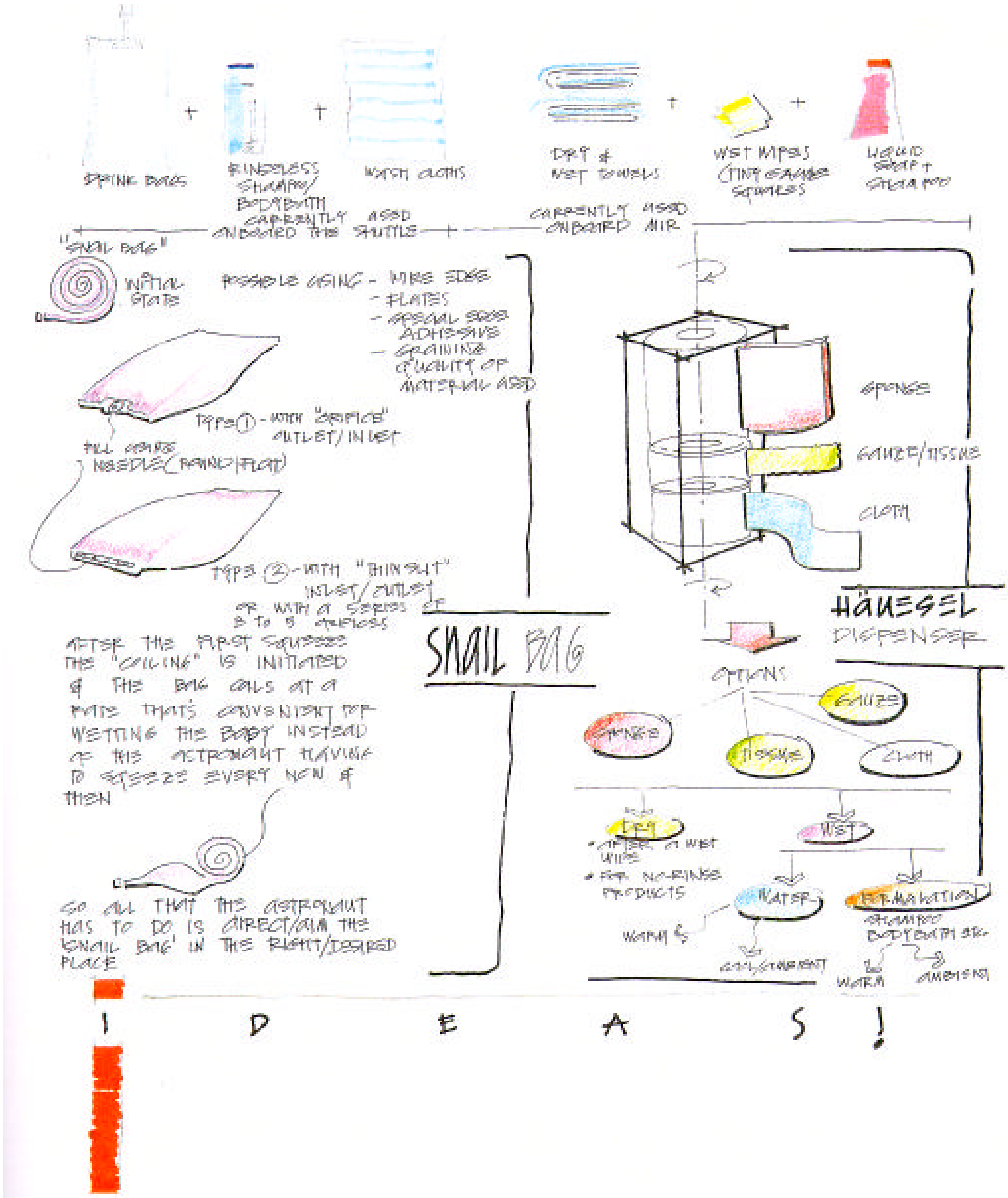
- The **foot hold** will be such that it can have variable positions as shown; it could also be one of those detachable - stowable foot holds.

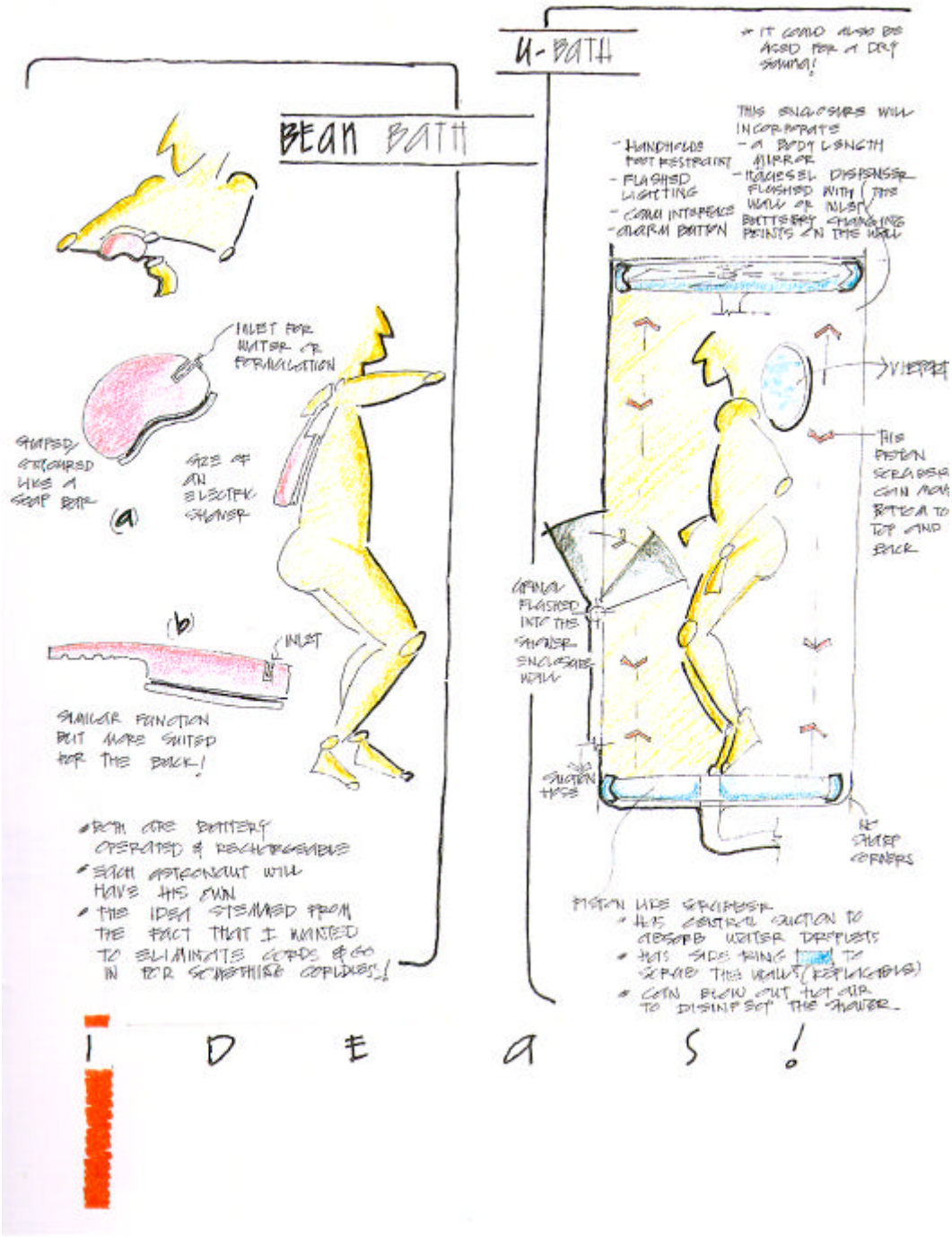
- It incorporates the **hausel dispenser** idea for whole body cleansing; this dispenser will allow the astronaut the following selection possibilities:

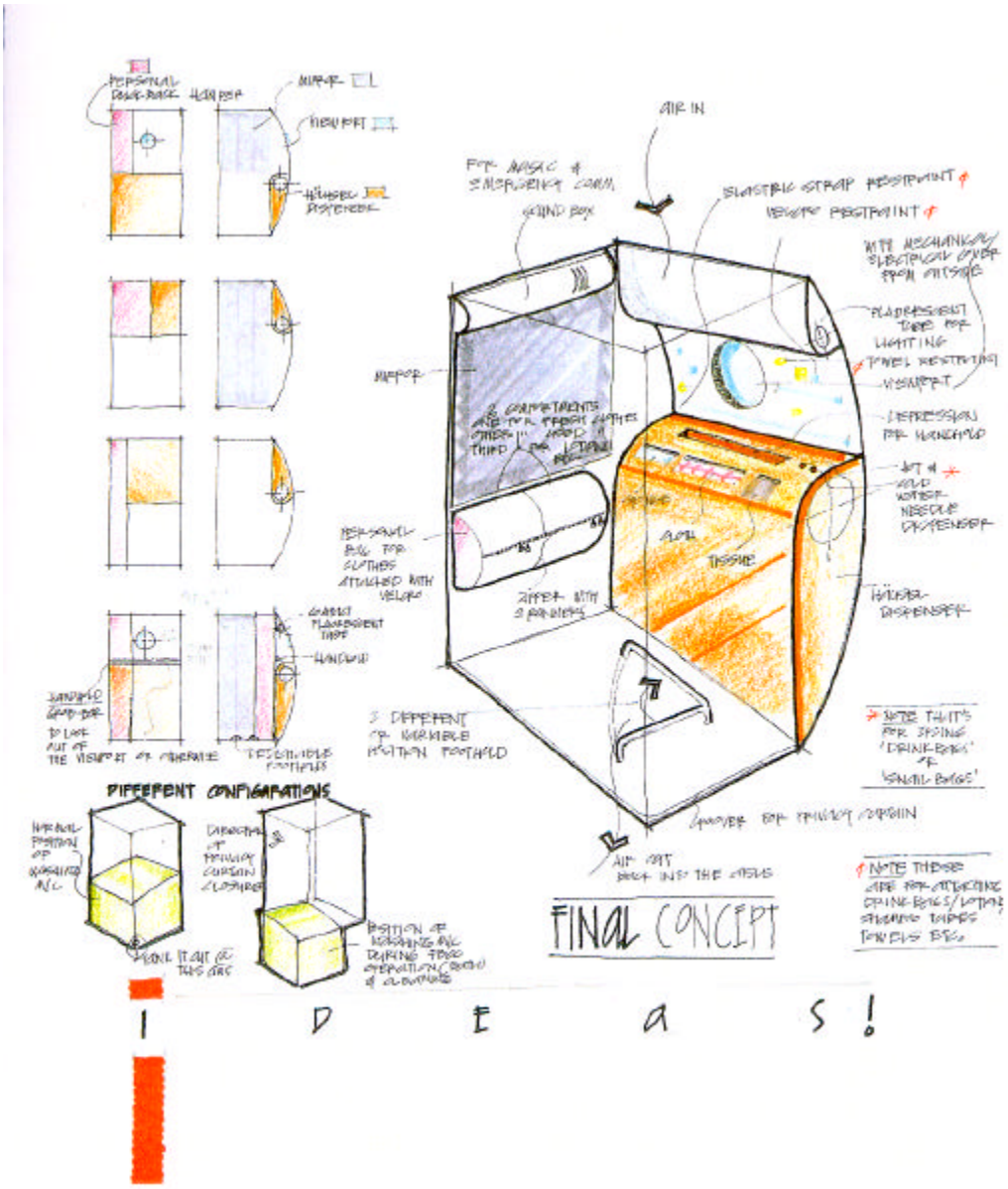


- These options will be made feasible by designing the appropriate **system** for it; also, one will have to design a **microprocessor-based programmable interface** to make the selection cater to the astronauts' needs and desires; for reasons of **safety** the interface should also include an alarm button for emergency/accident situations.
- The orientation will conform to the **1-g attitude** that the rest of the station conforms to; the rack will be positioned **next to the toilet** rack and it will be in a so-called **vertical** orientation.
- It will incorporate a large and real mirror specially made of a light material.
- Below the mirror will be Velcro patches to attach the **"personal bag"** of the astronaut; this bag
  - **will be transparent**
  - will be made out of a **light duck-back kind of material** (that does not retain any water on it)
  - **will be compartmentalized** into two sections--one for fresh clothes/lotions/creams/PHK etc. and the other for used clothes
  - will use **zippers** with two runners for each of the 2 sections
  - will have the two sections connected by Velcro and hence **can be detached from each other if desired.**


HOW MUCH WATER DOES YURI NEED?
GOT TO CLEAN UP THE SHOWER BEFORE VOLODYA COMES IN!
HEY THE FILTER IS CHOKED!
think!
HOW CAN I MAKE LIFE EASY FOR THE ASTRONAUTS??
a SHOWER THAT CAN
how about.... a THINKIN' SHOWER?
INTELLIGENCE


DRINK BAGS
RINSELESS SHAMPOO/ BODYBATH
WASH CLOTHS
DRY & WET TOWELS
WET WIPES
LIQUID SOAP + SHAMPOO
CURRENTLY USED ONBOARD THE SHUTTLE
CURRENTLY USED ONBOARD MIR
"SNAIL BAG"
INITIAL STATE
SNAIL BAG
HÄUESEL DISPENSER
SPONGE
GAUZE/TISSUE
CLOTH
OPTIONS
GAUZE
TISSUE
DRY
WET
WATER
I D E A S !


BEAN BATH
U-BATH
IDEAS!


AIR IN
MIRROR
FINAL CONCEPT
DIFFERENT CONFIGURATIONS
I D E a S !

- The sound box will be positioned above the mirror (see drawing).
- With the personal bag and the foot hold out of the rack, and with the privacy curtain open, it will be **very easy to clean the whole rack with a portable vacuum cleaner** periodically during the housekeeping.
- When not in use and with the privacy curtain open, this rack will give **extra' space onboard** for other activities if desired.
- It will have **fluorescent lighting with dimmer control flushed with the rest of the contours** so that the astronaut doesn't get hurt by a protruding light fixture; the light cover should be of a special material that doesn't heat up to dangerous temperatures.
- Between the lighting fixture and the hausel dispenser, a **window** (with an **external electrically operated safety cover**) should be incorporated; a connection to the outside can serve as an effective means of relaxation within a confined environment; and if the window can give an earth view— that would be excellent.
- Around the window one should provide **cross-cleats, Velcro patches and elastic straps for microgravity restraint.**
- The interior and the product **colours** and **textures** should be carefully selected to match the moods and the functions for which the rack is intended and such that they blend well with the decor of the rest of the station.
- Last, but not the least, provision must be made to incorporate the air **revitalization system** into this rack for ensuring a good, smooth, clean and comfortable air flow.

14 The Conclusion

14.1 Conclusion

The final concept described and drawn in the previous section should now be taken up for **detailing**, both from an **engineering standpoint** and **from an industrial design standpoint** to come. up with an optimum system for Zero-g Whole Body Cleansing onboard ISS Alpha.

It will also have to be **tested onboard the KC-135** because exposure to a microgravity environment will help identify the flaws, facilitate modifications and ensure smooth operation of the final system onboard the ISS.

It is also crucial that **during the design, development, testing and fabrication of this system**, not only should engineers, designers and human factors experts be included in the team, but also the **astronauts who have had long-duration Space stay experience**--that is vital to the success of the design process because the astronauts will be the real users of this system.

Abbreviations

CUA	Commode Urinal Assembly
EVA	Extravehicular Activity
FBCC	Full Body Cleansing Compartment
ISS	International Space Station
LSM	Life Support Module
MAG	Maximum Absorption Garment
PHK	Personal Hygiene Kit
PHS	Personal Hygiene System
RS	Russian Segment
SM	Service Module
SSF	Space Station Freedom
UCD	Urine Collection Device
WBS	Whole Body Shower
WMC	Waste Management Compartment

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Document ref. no. JSC27242
Produced under contract by Lockheed Martin Engineering Sciences, under subcontract to the Johnson Engineering Corporation, for NASA Johnson Space Center Flight Crew Support Division, Houston

2. **"Skylab"**, pg. 10-23 to 10-28
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Skylab Program Office, NASA Marshall Space Flight Center, Alabama, Oct. 1974

3. **"Development Program for a Zero-g Whole Body Shower"**
pg. 1, 2 and 13,
Garcia, Rafael and others--NASA Lyndon B. Johnson Space Center, Houston, TX, 1985

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Volume 1 -- Phase 1 Test Results, pg. 5-1 to 5-3
Document ref. no. JSC23014
Garcia, Rafael and others, Space and Life Sciences Directorate, Man Systems Division, NASA Lyndon B. Johnson Space Center, Houston, TX, June 1988

CREW DEBRIEFS

1. "SL-3 (Skylab -3) Crew Debriefing-Systems", tape #1, side #l, Lyndon B. Johnson Space Center, NASA

2. **Debriefs of Norman Thagard (approved version), Shannon Lucid (draft sent for approval) and John Blaha (draft)**, *Flight Crew Support Division*, Lyndon B. Johnson Space Center, NASA

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John Blaha
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and
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Natalie and **Cuong**
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Barbara, Thomas and Klaus--my buddies...my crew!

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13. ABSTRACT *(Maximum 200 words)*

NOTE: This document was originally published in 1997 as a International Space University Master of Space Studies student's project. While the specifics may be a little dated, the results gleaned are still relevant and valid.
Johnson Space Center is now abuzz with preparations for the International Space Station. The work on the various systems for the U.S. Habitation Module will begin in l998. As a prelude, the Flight Crew Support Division perceived the need to take a closer, more critical look at planning the Whole Body Cleansing function for ISS. This report is an endeavour to retrieve all data available on whole body cleansing mechanisms used, past and present, by the Russians and the Americans, analyze it and create design concepts for products/product systems for zero-g whole body cleansing on ISS Alpha, for typical duration of about 90 days. This report takes a close look at the Skylab collapsible shower, the Mir shower/sauna, the full body cleansing methods currently in use onboard the Space Shuttle and Mir and at the Whole Body Shower designed and tested for Space Station Freedom. It attempts to "listen" carefully to what the Mir astronauts (Norm Thagard, Shannon Lucid and John Blaha) have to say about their personal hygiene experiences during their recent stays on Mir. The findings in the report call for a change in paradigm. What is good for Earth conditions is not necessarily good for Zero-g! It concludes that a shower is not a good idea for the ISS. The final concept that is proposed reflects very strongly what the Mir astronauts would like to have and to use onboard a station like the ISS. The report concludes with directions of how to take the "idea" further and realize it in the form of a product system for Whole Body Cleansing onboard the ISS.

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