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The Apollo Medical Operations Project: Recommendations to Improve Crew Health and Performance for Future Exploration Missions and Lunar Surface Operations

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Acronyms

ARDIG	Advanced Requirement Development Integration Group
BM	Bowel Movement
CA####	CARD Requirement number
CAD	Coronary Artery Disease
CARD	Constellation Architecture Requirements Document
CDR	Commander
CEV	Crew Exploration Vehicle
CM	Command Module
CMP	Command Module Pilot
CSM	Command Service Module
CxCB	Constellation Control Board
EARD	Exploration Architecture Requirements Document
ECP	Exercise Countermeasures Program
EMU	EVA Mobility Unit
EPSP	EVA Physiology Systems and Performance
ESP	EVA Systems Project
EVA	Extravehicular Activity
ExMC	Exploration Medical Capability
GI	Gastro-Intestinal
HRP	Human Research Program
HS####	HSIR Requirement number
IR	Infrared
ISS	International Space Station
JSC	Johnson Space Center
LAT2	Lunar Architecture Team 2
LADTAG	Lunar Airborne Dust Toxicity Analysis Group
LBP	Low Back Pain
LEVA	Lunar EVA
LM	Lunar Module
LMP	Lunar Module Pilot
LSAM	Lunar Surface Access Module
MAG	Maximum Absorbant Garment
MCC	Mission Control Center
MORD	Missions Operations Requirements Document
PMC	Private Medical Conference
POGO	Partial Gravity Simulator
PRD	Personal Radiation Dosimeter
PVC	Premature Ventricular Contractions
R&R	Rest and Relaxation
RFID	Radio-Frequency Identification
SRD	Systems Requirements Document
STS	Space Transportation System
TEC	Trans Earth Coast
TLC	Trans Lunar Coast
UCD	Urine Collection Device
WBC	White Blood Count

Abstract

Introduction. Medical requirements for the future Crew Exploration Vehicle (CEV), Lunar Surface Access Module (LSAM), advanced Extravehicular Activity (EVA) suits and Lunar habitat are currently being developed. Crews returning to the lunar surface will construct the lunar habitat and conduct scientific research. Inherent in aggressive surface activities is the potential risk of injury to crewmembers. Physiological responses to and the operational environment of short forays during the Apollo lunar missions were studied and documented. Little is known about the operational environment in which crews will live and work and the hardware that will be used for long-duration lunar surface operations. Additional information is needed regarding productivity and the events that affect crew function, such as a compressed timeline. The Space Medicine Division at the NASA Johnson Space Center (JSC) requested a study in December 2005 to identify Apollo mission issues relevant to medical operations that had impact to crew health and/or performance. The operationally oriented goals of this project were to develop or modify medical requirements for new exploration vehicles and habitats, create a centralized database for future access, and share relevant Apollo information with the multiple entities at NASA and abroad participating in the exploration effort.

Methods. A review of medical operations during Apollo missions 7 through 17 was conducted. Eleven categories of hardware, systems, or crew factors were identified during preliminary data review generating 581 data records, which were captured in an Access database. The preliminary review resulted in 285 questions which were posed to surviving Apollo crewmembers using mail, face-to-face meetings, phone communications, or online interactions. Crewmember responses to these questions formed the basis for recommendations to items in each of the categories.

Results. Fourteen of 22 surviving Apollo astronauts (64%) participated in the project. Approximately 236 pages of responses to the questions were generated based on the Apollo experiences, with 107 recommendations garnered for future vehicles, habitats, EVA suits, and lunar surface operations.

Discussion. The Apollo medical operations recommendations are being incorporated into the exploration mission architecture at various levels: 21 recommendations either validated, revised or created new requirements, 4 are currently in practice, 34 are being evaluated, and 54 are being considered. A centralized database has been developed, and the recommendations have been presented to the different organizations involved with building the new vehicles, habitats, suits, or systems that may impact crew health and performance.

Conclusions. The Apollo crewmembers' input has proved to be an invaluable resource to a multitude of departments beyond space medicine. We will continue soliciting input from this group as we evolve and refine requirements for future exploration missions.

1.0 INTRODUCTION

The Apollo program, which began in January of 1966, was comprised of 18 missions: 12 crewed missions (including the Apollo 204 mission with Virgil "Gus" Grissom, Ed White, and Roger Chaffee) and six crewless missions which tested the capabilities of the Saturn rocket components[6]. The Apollo 7 mission heralded the first successful crewed mission, and in July of 1969, Apollo 11 fulfilled John F. Kennedy's mandate to send a man to the moon and return him safely home[7]. Twenty-six men flew Apollo missions, including four repeat flyers. Of the manned missions, six flights conducted between July 1969 and December 1972 successfully landed 12 humans on the lunar surface and returned them to the Earth.

In January 2004, President George W. Bush committed the United States to the further exploration of space[8]. This new vision for space exploration has the benefit of the cumulative knowledge and experience gained from the Apollo program. The exploration effort will require the development of new vehicles to transport crews from Earth to the lunar surface and for transportation while on the moon. In addition, crew will need (EVA) suits and extended duration habitation elements for the lunar surface operations[10]. The Crew Exploration Vehicle (CEV) and Lunar Surface Access Module (LSAM) though slightly larger, will bear many similarities to the Apollo Command Module (CM) and Lunar Module (LM). The EVA suits may serve the dual function of a launch and entry suit as well as the lunar surface suit. Lunar habitation is a new frontier, enabling humans to live on the moon for extended periods in order to conduct science experiments and use the lunar environment for in-situ resource utilization.

During previous studies, Apollo astronauts provided input into the engineering and mechanical aspects of EVA suit system designs [2]. However, no study has specifically addressed the impact of the Apollo vehicles, hardware, and systems on crew health or performance throughout all mission phases, including lunar surface operations and the influence of that impact on the new exploration vehicles and mission architectures.

To identify Apollo mission issues that had impact to crew health and/or performance and were relevant to medical operations, the Space Medicine Division requested a study in December of 2005. The goals of this project were to develop or modify medical requirements for new vehicles and habitats, create a centralized medical operations database for future access, and provide this knowledge to the multiple directorates at NASA-JSC participating in the exploration effort. Secondary objectives included using this information to validate current requirements and refresh knowledge regarding lunar operations in an effort to reduce programmatic risks and risks to crew health, productivity, and safety. The Space Medicine Division study and this paper are not intended to be a review of information contained in previous publications, such as *Biomedical Results of Apollo*.

Due to the multidisciplinary operational focus of this study, the target audience is diverse. This audience includes flight surgeons, engineers, and scientists developing the medical requirements for exploration vehicles, habitats, and suits, the mission planners developing crew timelines, and experts supporting behavioral health and performance.

Various aspects of this report will be of interest to a broader readership outside the medical operations community. Therefore, the report is written in a medically non-attributable format accessible to anyone with an interest in the Apollo program.

The Apollo Medical Operations Project was headed by Rick Scheuring, DO, MS, UTMB/Wyle Labs flight surgeon, James D. Polk, DO, MS, Manager of Medical Operations at JSC and Josef Schmid, MD, also with Medical Operations at JSC. The team included other flight surgeons from the Medical Operations office at JSC and University of Texas Medical Branch, Galveston, as well as project scientists and engineers within the Space Life Sciences Directorate (SLSD) and the Mission Operations Directorate (MOD) at JSC. Participation of the Apollo astronauts was solicited through the Space Medicine Division.The team would like to acknowledge of the enormity of the task and express an appreciation to the Apollo crews for discussing their missions which occurred at a time when most of the team members were still children.

2.0 METHODS

This section addresses the spectrum of approaches taken to assimilate, categorize, and assess the data.

2.1 Background Research

Background research was undertaken by the Apollo Medical Operations Project team to maximize the benefits from the study. The approach taken consisted of the following:

- Identify specific medical-related problems, if any, in each area associated with the operational environment during all mission phases
- Define the impact on crew health and/or performance
- Identify problems that recurred or were fixed on subsequent missions
- Develop an integrated, comprehensive set of questions that could be used in a face-to-face meetings with the Apollo astronauts

The impetus to “do our homework” before meeting with the astronauts came from the Apollo crewmembers themselves[11]. The crews voiced annoyance at discussing subjects or responding to questions that had previously been published. Therefore, it was incumbent upon the team to research areas and develop questions not previously documented.

Review of Apollo resources pertaining to Medical Operations and the sources of data included: Apollo medical mission debriefs (7-17); Apollo flight surgeon logs (7-17); Apollo biomedical engineer logs (7-17); Apollo mission commentaries (7-17); Apollo mission reports (11-17)[13]; Apollo lunar surface journals (11-17)[3]; preliminary science reports (11-17)[12]; the Apollo lecture series[11]; Apollo videos; NASA technical

memorandums, related papers[2,14,15,16,17,18]; and personal communications with the crewmembers through email, phone or direct contact. These materials were reviewed by the team to understand the Apollo astronauts' experiences and the issues impacting their health and/or performance as previously reported. It is important to note that the medical debriefs and flight surgeon/biomedical engineer logs are considered medically confidential material and subject to the Medical Privacy Act of 1974. All other resources are available to the public. It is equally important to note that some issues identified in the debriefs were detailed in the crew logs, crew questionnaires, or air-to-ground communications but were unavailable. Every attempt was made to fill in the missing information from available resources for this study.

After reviewing historical data, the team identified eleven categories within the operational environment occurring during Apollo 7-17 that had impacts to crew health and/or performance. The data assembled into these categories formed the basis of the questions used to interview the Apollo astronauts. The categories included EVA mobility unit (EMU) and EVA suit issues; lunar surface operations; inflight illnesses; medical kit, medications, or bioinstrumentation; environmental (vehicle); radiation; exercise; food and nutrition; performance and human factors; crew schedule; launch, re-entry, and recovery; and flight surgeon-crew interactions. Certain well-documented areas relating to crew health or performance, such as lunar dust, were identified but not covered in detail during this study. Likewise, areas that affected the Apollo crews but were not relevant to the new vehicle design, such as the Apollo water chlorination system, were identified in the data collection but were not addressed during the face-to-face meetings.

2.2 Data Collection

The historical data collected was organized and compiled into an Access database (Appendix A). This database facilitated the search capabilities of the team in identifying areas that had health and/or performance impacts. The data was organized by mission, source of information, topic (category), medical/hardware issue, crewmember involved (if applicable), description of the problem, general comments about the issue, and resolution/reoccurrence. Questions related to the issue were generated from this body of data. The team used this method, to create 581 data records. An example of one record is provided in Figure 1. Note that any attributable medical information contained in Appendix A has been removed for the purpose of this paper and exists as a separate document.

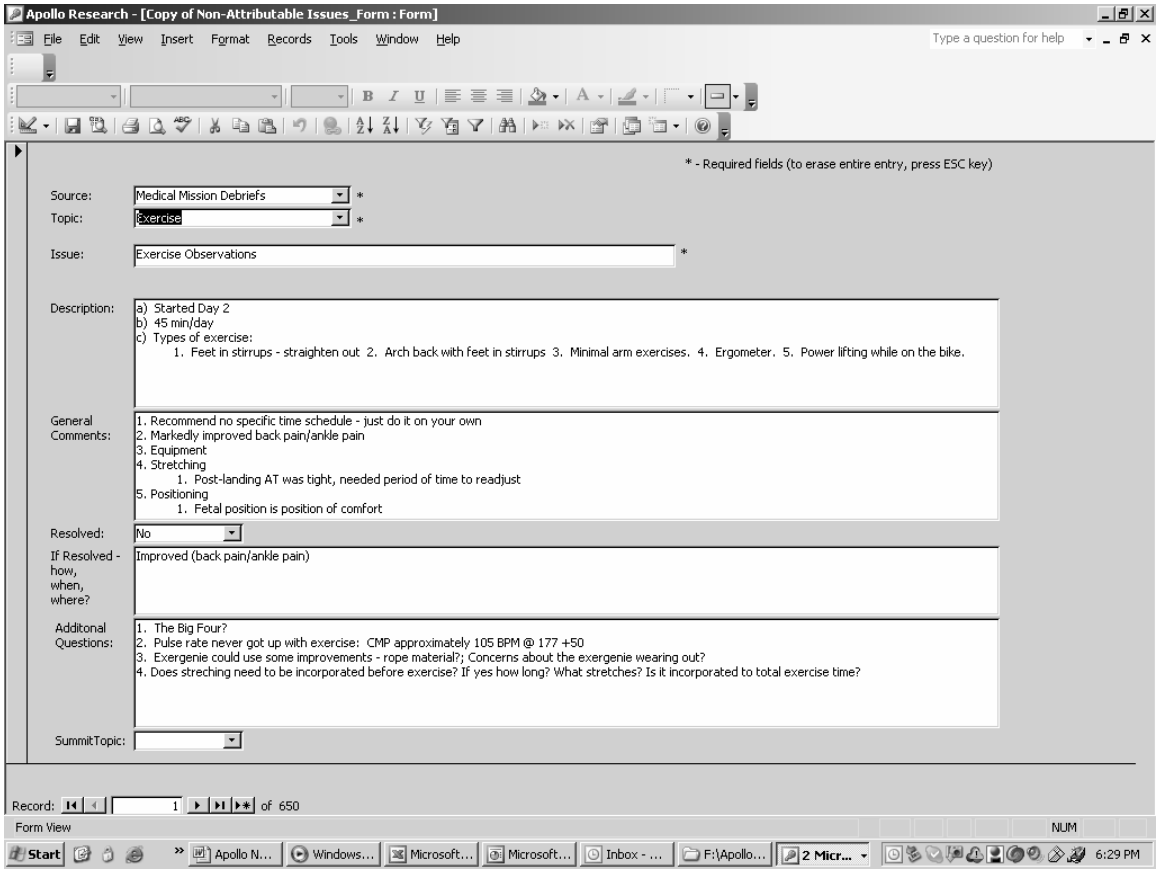

Figure 1. Sample Access Data Record From the Apollo Medical Operations Project

2.3 Panel Questions

Questions were generated from the historical data search effort and from operational and research disciplines associated with each category (Appendix B). These questions were augmented with others solicited from discipline leads in each category. The categorized questions were reviewed by flight surgeons and current astronaut physicians at JSC for relevance and operational applicability to the exploration effort. This resulted in a final list of 285 questions used during the face-to-face meeting with the Apollo astronauts.

2.4 Face-to-Face Summit

The face-to-face summit with the Apollo astronauts was held in June of 2006 in Houston, Texas. Per the crewmembers' request, Days 1 and 2 were closed sessions limited to Apollo crew, the current flight surgeon cadre and astronaut physicians. Day 3 was limited to invited guests and the Apollo flight surgeons. Of the original 29 Apollo astronauts, 22 survive today and were invited to participate in the face-to-face summit (Appendix E). Dr. Joseph Kerwin, who served as CAPCOM for Apollo 13 and astronaut physician on Skylab I, was a project team member and invited to participate as an astronaut. The invited guests for Day 3 submitted questions to the Apollo Medical Operations Project

team prior to the meeting to insure the appropriateness of the question and to facilitate interaction with the crewmembers during the session.

Prior to the panel question discussion on Days 1 and 2, the project team presented informational briefings to achieve the intended outcome of the meeting. The two-fold purpose of the meetings was to capture the experiences of the Apollo astronauts to validate findings from the historical data search and to project applicable aspects of Apollo operational experience to the exploration initiative. The project team presented the issues that faced the crews during their missions from the historical data research to increase their awareness of the current knowledge base. It also served to stimulate memories garnered three and a half decades ago. The presentation concluded with a discussion of the exploration architecture to familiarize the participants with the new strategies and mission plans.

The panel discussions were held with the astronauts and project team members meeting in one room. A professional transcriptionist recorded all comments from the astronauts and later organized the responses with the corresponding questions. The Day 3 session was conducted in a similar manner by the team and transcriptionist. This document was then reviewed by the project team for accuracy and clarification. Notes taken by the panel team during the question sessions were added to the document as necessary.

2.5 Post-Summit Review and Validation

The purpose of the post-summit phase was to compile the accumulated responses to the panel questions and then organize the responses into a comprehensive report (Appendix B). Apollo astronauts who participated in the face-to-face summit reviewed and validated the report. They also submitted additional input and points of clarification. After review by the project team, the updated version including recommendations was then submitted to all the Apollo astronauts providing an opportunity for an additional six crewmembers not attending the face-to-face meetings to participate. These responses can be found in Appendix G.

3.0 RESULTS

3.1 Data

Sixty-four percent (14 of 22) of the surviving Apollo astronauts participated in the project. The combined crewmember responses to the 285 questions generated from the background research resulted in 236 pages of data. A comprehensive review of all the responses from the astronaut sources revealed 107 recommendations that was subsequently broken down into 113 recommendations for easier data analysis (Appendix C). The input shown in Table 1 formed the basis of the Apollo Medical Operations Project recommendations. Note that the total number of astronauts participating includes

the eight attendees plus the responses to the post-summit report and questionnaire which included both attendees (4) and non-attendees (3).

Table 1. Astronaut Attendance and Participation at the Apollo Summit

Number of attendees	**8**
Post-summit full responses	7
Total number of Apollo astronauts input	14
Number of Apollo astronauts available	22

The panel discussion questions and answers document is broken down into the number of questions per category, the responses from the post-summit participants, and recommendations per category in Table 2. Note that this section is only post-summit responses and does not include the eight summit attendees' responses, which could not be individualized. Note that the "Post-Summit # of Responses" column refers to the number of responses given within that particular category to the document that was sent to all astronauts following the face-to-face meeting.

Table 2. Post-Summit Questions, Answers and Recommendations. Listed below is the number of questions in each of the categories with number of post-summit participant responses and validated recommendations. Note that the number of categories is further broken down into subsections of the main category where bolded.

Category	# of Questions	Post-Summit # of Responses	Recommendations
EMU/EVA Suit	63	30	13
Lunar Surface Operations (ops)	36	20	16
In-flight Illnesses/**Medications**	16	24	9
Medical Kit	3	4	4
Bioinstrumentation	3	5	0
Environmental Impacts	35	75	16
Radiation	5	4	5
Exercise	20	33	8
Food Nutrition	28	76	8
Performance/Human Factors	16	48	11
Crew Work-Rest Schedules	10	30	5
Launch/Landing/Recovery Operations	34	121	10
Flight Surgeon Crew Interaction	2	7	2
General Questions	14	31	0
Totals	**285**	**508**	**107**

4.0 OPERATIONAL AND RESEARCH RECOMMENDATIONS BY CATEGORY

4.1 EMU/EVA Suit

1. *Improve glove flexibility, dexterity, fit*. According to the Apollo lunar crews, the most fatiguing part of surface EVA tasks was repetitive gripping. Regarding the glove, one crewmember stated, "*Efficiency was no more than 10% of the use of the hand*." The fingernails generally tended to be pulled back resulting in separation of the nail from the bed, or onycholysis. Additionally, the skin frequently was abraded from the top of the knuckles. This event took on operational and potentially mission significance as several lunar walkers stated that they would not be able to work in the glove beyond the two to three EVAs they completed due to the swelling and pain over the bony prominences of the metacarpal phalangeal (MCP) and proximal interphalangeal (PIP) joints (knuckles), although had they been asked, it is probably that at least one more EVA would have been possible. It is also interesting to note that the lunar crews stated that they did not experience hand or forearm trauma in training, though muscle fatigue occurred. However, these training sessions typically lasted only two to three hours whereas the lunar EVAs plus pressurized prep time were seven to nine hours in duration. [Note: Recent experience with ISS-related EVAs suggests that better conditioning can solve most of the forearm fatigue problems; however, lack of dexterity and hand trauma remain as critical issues. (For perspective, you may wish to expand on the ISS experience as it relates to future lunar work.)] In terms of flexibility and fit, the glove should come as close to Earth-normal use of the hands as possible. Lowering the pressure [in the suit] was suggested, i.e., the less strength it takes to manipulate the glove, the less physically tasking to the hand and forearm musculature. This can also be accomplished by reducing the glove bulk and making the bladder thinner. Other glove recommendations included:

- Gloves should be custom designed for each crewmember and should incorporate mechanical closure for gripping
- Designers should consider a wrist seal and depressurized glove
- Robotic power-assisted glove should be used for repetitive tasks
- Special inner bladder surfaces should be developed and glove liners should be worn to prevent skin chaffing and abrasions

A consensus statement made by the Apollo astronauts who participated in the project on the EVA suit issue was that given a fixed budget for suit development and improvement, the funding for the new suit would be best spent in improving the glove. If money is left over for other components, then address those issues, but fix the glove first.

2. *Reduce the mass of the suit by a factor of two*. Once the glove issues have been addressed, reducing the suit mass would help. Availability of recharge of consumables during EVA should be strongly considered. Despite suit bulkiness, the astronauts cautioned that suit mass was an asset to some extent in the partial gravity environment. It provided an inertial point of reference that allowed them to adapt to 1/6 g. (But that point is always going to be there as long as some significant mass is present – i.e., body, suit,

and backpack.) Reducing the suit mass too much would remove the familiarity the crewmembers relied on and may predispose one to falls.

3. *Increase general mobility by a factor of four*. EVA suit mobility was more of an issue in terms of surface locomotion and energy expenditure. The crews often felt they were fighting the resistance in the suit (including in the glove as mentioned above). This was fatiguing, especially in the thighs. The astronauts pointed out that the lunar surface is more similar to an ocean than to a desert. The undulating surface posed a number of challenges, including ambulating against a suit that did not allow mobility at the hip. Normal human locomotion includes flexion at the hip and the Apollo A7LB had limited ability to bend the suit at the hip and to rotate within the suit. The crewmember had to bend forward from the knee joint, which demanded considerably more work load on the quadriceps muscles. Therefore, the mobility recommendations centered on adding hip mobility and improved knee flexibility. One comment summed this point well, "*Bending the knee was difficult in the suit. We need a better [more flexible] knee joint*."

Reducing suit pressure to ~3.0 psia (sea-level oxygen partial pressure) with a pure oxygen system would accomplish this to some extent. However, the crews understood the limitations with using this approach to improving suit mobility. Namely, the risk of decompression sickness would be increased and the margin of safety with a suit puncture would be decreased (This risk could be mitigated by an emergency regulation of oxygen flow to maintain 3.0 psia). It was also pointed out that lowering suit pressure may remove some of the suit extremity splinting effect and could predispose to limb injury, which was generally not a concern at the Apollo suit pressure of 3.75 psia.

4. *Lower suit Center of Gravity* (CG). Although this area has garnered considerable attention recently with new suit design, the crews felt it was not a main issue, compared to the glove issues or suit mobility. They reported adapting to the suit CG quickly on the lunar surface, which was described as "*aft and slightly high*." A number of crewmembers stated *"Don't make moving the CG your primary priority. Move the CG only if it becomes convenient to do so while taking care of other issues like reducing the mass of the suit, fixing the glove, etc."*

5. *Develop a system that prevents helmet fogging during heavy exertion*. Although the lunar walkers did not experience fogging of their visor while on the moon and used an anti-fogging wipe to prevent it, its possible occurrence could be catastrophic. An example for potential adverse effects due to visor fogging was the Apollo 11 mission. Crewmembers remained in their suits during recovery operations for quarantine concerns. The visor fogged once the CM was opened to the humid, warm South Pacific air, completely obscuring their vision. One crewmember became very concerned during transfer from the CM to the rescue basket, as he was unable to clear the visor to see where he was going. Whether it was due to exterior fogging due to the cooler visor causing condensation to occur on the visor or that there was no anti-fog wipe available or used is unclear. The implications on the lunar surface are obvious. Visor fogging needs to be eliminated as a concern, especially if a contingency situation occurs where the crewmember is physically exerting him or herself for extended periods of time.

6. ***Improve peripheral vision by adding neck ring*** **(movable joint)**. The surface crewmembers stated, "*You would always have to turn your body* [and the suit] *to see to the side*." The astronauts' inability to see their feet during lunar operations, partially due to the large camera mounted on their chests, made working close to the suit difficult at times. Helmet design should allow the astronauts to see their feet while working and traversing the surface of the moon. Another participant concern was the inability to see their arm during a fall to the side, which occurred with some frequency. A movable neck ring, such as the Navy deep sea diving helmet with rotating neck ring, is a good option and should be considered in the new suit design. One lunar crewmember added a slightly different experience: "*I never found walking and running difficult for the same reason it is not difficult on Earth, i.e., your brain integrates location of the potential obstacles with where your foot will land in order to avoid those obstacles*."

7. ***Develop a reliable Heads-up Display*** **(HUD)** ***displaying consumables information, limited biomedical*** **(BIOMED)** ***data, navigation and position data on demand***. The crews felt the HUD should primarily present the operational information that you need in an instant, e.g., if you want to see oxygen consumption, you say "oxygen" and it appears on the display. Crew did not feel a pressing need to know their heart rate, metabolic rate, or other physiological information during an EVA as in a continuous display. However, a heads-up display would be acceptable with limited physiological information on demand. Certain flexibility in reprogramming should be possible in anticipation of greater demand for information with longer and more complex EVA sequences. A concern expressed by one participant was to avoid increasing the complexity of the system to the point of reducing its reliability; however, the other crewman and telemetry and communication links provide a clear backups to the HUD information if needed.

8. ***The lunar boot functioned well and does not need to be improved***. The boot was very comfortable; however, it was slippery on rocks or boulders that had some regolith covering that reduced friction. Generally this was not regarded as a problem during the surface operations. Concerns regarding "slipping" in the moon regolith were unfounded. The lunar regolith has a high, gross coefficient of friction and is well packed beneath the upper one cm or so of loose material. This property helped maintain the crewmembers footing despite its "slippery" or "loose" appearance. There was not concern about ankle sprains or injuries with falls due to the lunar soil although one crewman strained a shoulder with extreme exertion and another noted some slight discomfort at the site of an old knee tendon sprain with extended side-hill traversing.

9. ***Use a self-sealing pressure garment within the suit in case of puncture***. EVA suit puncture hazard was a primary concern of the lunar astronauts, although the risk was considered low. Astronauts suggested that protecting suit occupants from a break in suit integrity was appropriate for future research and development activities. However, the trade-offs for this need to be considered carefully relative to mission rules if there is a puncture and emergency regulation of suit pressure and the availability of rover consumables, etc.

10. ***A drink bag should have capability to contain a high-energy liquid in addition to having a bag with plain water*****.** The A7LB suit had a 15-ounce drink bag, an amount

considered insufficient for the crews on the surface. Typical lunar surface activities may last up to 7.5 hours, but the total time in-suit from don-to-doff could be up to 10 hours. The astronauts strongly agreed the amount of liquid beverage contained in the suit needed to be increased for future crewmembers, including separate capabilities for plain water and a non-caffeinated high-energy drink. In addition, pre-donning checklists should include a standard procedure to load up on water, plus and adequate urine collection device (see below).

11. ***Develop a better in-suit Urine Collection Device* (*UCD*) *that will work in 1/6 g*.** The UCD provided to the crewmembers for use in the suit was a device requiring proper fitting of an elastic connector that worked for some and did not work for others. Urine leaks sometimes resulted in skin irritation. In one case, the elastic connector was too tight on the first EVA, resulting in some injury during forced urination. This problem was solved for subsequent EVAs by stretching the remaining connectors on the LM hand-controller between EVAs.

12. ***The suit should be a low pressure* (3.50 psia), *single gas system***. Referring to recommendation #3, the crews stated that testing a lower pressure suit should be considered but suggested a lower pressure of 3.50 psia at 100% oxygen. Reducing suit pressure to ~3.0 psia (sea-level oxygen partial pressure) might be considered with a pure oxygen system. The risk of a suit leak could be mitigated by an emergency regulation of oxygen flow to maintain 3.0 psia .

13. ***Protect the suit zipper function***. The Apollo A7LB suit was a single zipper system, unlike the Gemini suit which was a double-zipper system. The lunar dust was difficult to clear from the zipper and impaired normal function on each subsequent lunar EVA for some missions. Other missions had no problems with adequately cleaning the zipper. The abrasive nature of the dust scored the metal connections, primarily circumferencially on the bearing surfaces. The lunar dust exposure did not result in a breach of the sealing capability of the suit however repeated exposures may increase this risk.

4.2 Lunar Surface Operations

Among the lunar surface operations recommendations, crew scheduling, feasibility of surface activity commencement, and airlock/hatch design was given particular importance for the exploration architecture. The key recommendation is that because EVA efficiency is extremely valuable with respect to freeing the crew to do what humans do best, i.e., we must use crew experience and training to react instantaneously to new and unexpected situations and to use their brains, eyes and hands to take advantage of that experience and training. Routine and repetitive tasks should be as automated as possible, particularly those tasks related to the determination of position and to sample and other science and operational documentation.

14. ***Schedule crews for two Lunar EVA* (LEVA) *days on and one day for maintenance, alternating crews throughout the week***. The surface walkers were adamant that surgeons protect the future lunar crews from overwork. Multiple factors allowed the Apollo lunar crews to work and stay awake for long periods of time during

their relatively short stay: disruption of normal circadian rhythm influencing wake-sleep cycles; loud ambient noise levels in the lunar module (LM) (the exact background noise level was not measured according to Jerry Goodman, Apollo vehicle engineer); and crew psychological state, i.e., the lunar astronauts were excited considering their current circumstances. The ability to sleep varied significantly. For some sleep was described as very restful, but for others it was described as a couple of hours of "nodding off" on the lunar surface. The astronauts stated that to optimize crew performance for extended stays on the moon, the schedule should never allow for more than two days of LEVA consecutively without a day of rest or for the alternation of EVA teams, with one acting as support on the day of rest. On extended stays, one day per week would be considered an intravehicular activity (IVA) day spent performing suit maintenance or planning and preparation for future field activity. A crew of four could alternate this schedule thereby protecting the crewmembers from overwork.

15. ***The hatch and ingress corridor should be sized appropriately for an inflated 1/6 g pressure suit***. A curious finding during the background research involved reviewing the individual crewmembers metabolic activity during their lunar surface activity. All the crewmembers had notable increases in their metabolic rate during the last 30 minutes of their 3.5 to 7.5 hour LEVA. The initial assumption was that the crews were deconditioned from their micro- and partial-gravity exposure thereby reducing their exercise capacity. However, the crews' stated sudden increase in energy expenditure had to do with the hatch design on the LM: the pressurized suits were too big and bulky to get into the hatch without bending and twisting their bodies. The position of the display keyboard above the hatch also prevented the crews from placing their hands in this area to gain leverage to pull themselves into the LM. This activity usually took several tries to ingress the LM and was quite a fatiguing process. Jerry Goodman, an Apollo vehicle engineer who helped with the LM hatch design, identified that the problem occurred before the vehicle arrived on the moon. Apparently the hatch design and pressurized suit design, although dependent and initially corroborated, later changed without being communicated to the other. The LM hatch size was decreased and the suit size increased and this went unrecognized until the crews attempted ingress to the vehicle on the moon.

16. ***An airlock may make ingress/egress easier and will also be a good idea from a dust control standpoint.*** Designing an airlock to separate the vehicle hatch from the habitation area could decrease the risk of tracking lunar dust into the lunar module.

17. ***Surface activities can begin once operationally feasible after landing***. Crews generally felt a little "wobbly" upon stepping on the moon, but this was attributed to adapting to the EVA suit CG and the partial gravity rather than the neurovestibular dysfunction experienced by crews upon return to the 1 g environment. This statement had been reported in the literature[20] and needed to be explained by the Apollo crewmembers to determine if this would be a problem for lunar crews in the future. Coordination seemed to improve steadily during first couple of hours on the surface. The crews did not experience recognizable problems with spatial orientation on lunar landing. This was a concern operationally as experience with rotary wing pilots suggests spatial disorientation and conditions known as "brown out" have contributed to mishaps. The commander and

lunar module pilots reported similar conditions during landing operations on several missions[14] but did not experience recognizable spatial disorientation.

18. ***There is no special training needed for 1/6 g EVAs other than a familiarization session***. The astronauts stated the limited training they received using the Partial Gravity Simulator (POGO) and parabolic flight aircraft was sufficient for preparing them for lunar EVAs. Future lunar crews would do well to use this as lunar familiarization training but should not engage in elaborate partial gravity training devices or environments as the human body quickly adapts to the 1/6 g environment of the moon.

19. ***Limit navigation into craters with a slope < 20-26°.*** Aside from the risk for injury on slopes greater than 20-26°, the crews reported that they had to use a side-stepping approach going up and down sloped terrain because of the limitations in suit mobility. This motion often placed the inertial mass of the suit and crewmember on one leg, which would tire after repetitive loading, either uphill or downhill. The slope of the terrain affected the ability to perform this motion and the crews estimated that 20-26° was the safe limit unassisted.

20. ***Crews requested that an automatic position determination device be available to aid navigation on the lunar surface***. All sorts of ambiguities exist on the moon, e.g., slopes, terrains, sun shadows, and bland environments. With the undulating terrain, it was very easy to lose known points of reference and geographic orientation despite being well versed in the two-dimensional topography. One lunar crewmember admitted to spending twenty minutes trying to re-orientate during the surface traverse. A navigation system available on the suit HUD and/or rover would be very helpful and save time during surface operations.

21. ***Ladder rung height and width on the LM were good but the glove did not allow adequate grip for safety***. Crews were able to ascend and descend the LM ladder without difficulty and felt the rung height and width were easy to use. Their only concern was related to the inability to adequately grip the rung or side rails due to the limitations in the glove (see EVA suit section). Ladder height could be a concern if the glove issues are not addressed, especially if the crewmember is carrying equipment or an individual up the ladder.

22. ***Ensure adequate water and food are available before and during lunar EVA***. Lunar EVA ranged from 3.5 to 7.5 hours. Total in-suit time for surface operations averaged 10 hours. The LM atmosphere was similar to the CM at 5.0 psia and 100% O_2 therefore no EVA pre-breathe period was required. It is generally recommended that humans should drink 4-6 ounces of fluid for every 30 minutes of moderate exercise to maintain adequate hydration status[21]. The Apollo crews stated that they became thirsty and hungry during their LEVA and suggested making available adequate amounts of high-energy food and plain water.

23. ***Lunar EVA should be performed as one continuous event***. The question was raised regarding LEVA and whether it should be broken down into two shorter duration events allowing the crew time to hydrate and replenish energy stores, etc., or as one continuous

event. The astronauts' inputs overwhelmingly supported the later choice as the suit and vehicle prep time for LEVA take up an unreasonable amount of crew time.

24. ***Risk factors for injuries identified***. The Apollo astronauts were queried about risky behaviors on the lunar surface or conditions that could predispose them to injuries. Overall, the crews felt the injury risk was low due to the partial gravity providing considerable time to react to a fall and the relatively short distance to fall considering their lunar weight was 1/6 their Earth weight. They were quick to mention that the videos of their falls on the moon were misleading, and that it did not hurt to fall. However, the crews pointed out that their inertial mass did not change on the moon. Given the EVA suit/PLSS (~194 lbs. on Earth) and crewmember mass and right set of circumstances listed below, sufficient energy could be applied to a joint or extremity to cause injury.

a) *Navigation into terrain or craters with slopes > 20-26°*. A fall on sloped terrain may be well tolerated unless the crew was moving or carrying an external load, such as equipment or rock samples. Although the exact angle of the slope was an estimate, the crews remarked that stable footing was limited and leg fatigue would become more pronounced in terrain steeper than approximately 26°. Lack of suit mobility, primarily at the hips, made getting in and out of steep terrain difficult. Another concern was the lack of peripheral vision in the suit and the inability to see where an outstretched hand might land. Hand or wrist injuries were more of a concern for some of the crewmembers than lower extremity injuries. The ability to estimate crater dimensions was compromised as mentioned by one crewmember in the following statement: "Reflective light in the shadows isn't as evident as on Earth. Craters did appear steeper visually. But we knew we had to go down into that crater, so it gave us concern."

b) *Rover activities*. The safety harness took roughly three minutes to fasten and some crews opted not to engage the buckle. The astronauts stated that the lunar module pilot in the right seat was at particular risk of falling out due to the undulating terrain and often being tilted downward and out the vehicle.

c) *Falling from a height*. Falling from the rim of a steep crater was a concern in some instances. Ladder height on the LM was less that six feet, but it became a concern with the poor glove grip mechanics. Mention of the proposed LSAM ladder height ranging from 20-28 feet drew sighs from astronauts and obvious concern for injury.

25. ***To ensure operational success and optimize performance of the crews, allow adequate time to practice mission activities in a variety of environments including analogs that allow preparation for off-nominal events***. The Apollo astronauts used at least five different 1 g analog environments for training and testing equipment. The crewmembers stated that training in a lunar analog environment prepared them for actual lunar surface operations. They also indicated that this training gave them confidence under nominal circumstances that they would be well prepared for off-nominal events.

26. ***Plan the operations on the surface so that you protect the crews from themselves***. This recommendation relates to the earlier recommendation about protecting the crews from overwork and burnout. Adequate time is required for the lunar crews to have mental and physical rest during and between LEVA to prevent mistakes and reduce the risk of injury.

27. ***With extended operations on the moon, establish all the experiments in the first week***. Related to the previous recommendation, the Apollo crewmembers were sensitive to the fact that lunar surface operations are difficult and demanding. Astronauts with longer surface-stay time would be more likely to make mistakes in procedures or handling equipment. Therefore, it would be good practice to deploy all the experiments and heavy load activity within the first week of a lunar stay to minimize error and injury risk.

28. ***A robot should perform routine, systematic, repetitive, menial tasks*** **(may help prevent repetitive use injuries)**. Physical tasks, such as surface drilling, moving equipment, and setting up experiments should be performed by automated systems where possible to minimize repetitive use injuries and free up crewmember time on the surface. Examples of overuse injuries include medial or lateral epicondylitis in the elbow (tennis or golfer's elbow), DeQuervain's tenosynovitis at the wrist, and shoulder rotator cuff injuries. These overuse injuries have been reported in astronaut training[22]. Other overuse injuries seen in microgravity EVA include fingertip and fingernail trauma. Repetitive use also poses a risk of associated space suit wear and tear.

29. ***The Rover should have the ability to recharge your suit***. The crews felt they could have performed longer LEVA but were limited to the consumables in the suit. A remote recharge station in the field or placed on the rover could potentially extend surface activity duration or be used in the event of a suit incident, such as a leak.

4.3 In-flight Illnesses

30. ***Low back pain should be treated with aggressive pre-mission and in-flight core strengthening program***. Some crewmembers complained of significant low back pain (LBP). LBP was noticed early on in space flight by >70% of crewmembers. Symptoms were relieved by curving back into the fetal position. Aspirin and other analgesics provided little to no relief. This has been a consistent finding throughout the space program[23]. Etiology is unclear but probably related to stretching of the fibers of the intervertebral disc's annulus fibrosis. Interestingly, the crewmembers denied exacerbations of LBP on lunar surface or return to 1 g. The astronauts suggested developing a preflight exercise protocol to strengthen abdominal muscles. This recommendation is consistent with musculoskeletal expert recommendation that abdominal or "core" strengthening pre- and in-flight helps improve lumbar spine strength and stability and may prevent or lessen in-flight low back pain[24].

31. ***Therapy to relieve muscle soreness, primarily in the forearms, must be available (improved glove design may assist this).*** All the lunar astronauts suffered from some

degree of forearm soreness during their surface activities. This soreness was related to repetitive grasping-releasing against resistance in the pressurized glove. Although the soreness improved overnight, this could result in overuse injury if the crew was subjected to consecutive LEVA. Therapy, such as non-steroidal anti-inflammatory medication, heat packs, and massage were offered as solutions by the crewmembers. The overall solution in their mind, however, was improving the glove design and adding mechanical assist with repetitive grasping-releasing motions.

32. ***Constipation: improve the waste management collection system***. Constipation was related to diet (low residue), low fluid intake, and waste management problems. Individual crewmembers intentionally "constipated" themselves with Lomotil in order to reduce the frequency or prevent bowel movements (BMs). One Command Module Pilot (CMP) went an entire 6-day mission without a BM.

33. ***Screen for CAD prior to selection for lunar missions***. The arrhythmia experienced during LEVA in one Apollo lunar crewmember was presumed to be related to hypokalemia (low serum potassium level) and dehydration on the lunar surface. This forced subsequent crews to take potassium supplements, which caused loose stools. Underlying coronary artery disease (CAD) was found years later as the cause of arrhythmia in this crewmember. Current CAD screening for ISS crewmembers is much more sensitive than the screening technology in the 1960s and should detect this condition in astronauts.

34. ***A physician crewmember would increase the comfort level among the crewmembers and can be cross-trained to do other activities.*** This was a consensus statement among the crewmembers regarding extended duration lunar operations. The Apollo crews had limited medical training and relied on input from the ground flight surgeon for medical issues (if they even acknowledged that a medical issue occurred). A physician astronaut could be cross-trained to carry out mission related activities, as demonstrated by Skylab, Space Transportation System (STS), and NASA-Mir programs. One Apollo astronaut remarked, "Hell, if they can take a naval aviator and train him to do geology [on the moon] they sure as hell can train a doctor to do useful things."

35. ***Adequate preventive measures and treatment for diarrhea must be available***. Another consensus statement by the crews was related to the bad experience using the Apollo waste management system. Unless this system is improved, loose or liquid stool contaminants in the cabin is very difficult to manage and clean. Fecal-oral contamination and infection also becomes an issue. Therefore, medications and/or dietary measures must be available to prevent its occurrence.

4.4 Medication/Medical Kits (Appendix D)

36. ***A card is needed in the med kit to inform the crew of the medication duration, indication, and interaction with other meds***. Confusion regarding use of medication, and more importantly, the duration of action occurred on several missions. This prevented crewmembers from using medications properly. One Commander (CDR) remarked that

he had forgotten how long Dexedrine lasted and suggested putting a card in the med kit to inform the crew of the medication duration, indication, and interaction with other meds. Crew felt they did not want to report any medication usage or other problems because of privacy concerns (a private medical conference (PMC) was not available on the early Apollo missions). In addition to this recommendation, crew education by the flight surgeon was requested to clarify drug duration of action and potential interaction with other medication. It is important to note that current STS and ISS medical kits have this information readily available to the crews.

37. ***Add non-sedating antihistamines for allergy symptoms due to lunar dust exposure***. Symptoms related to lunar dust were described like as "allergies" with runny nose, nasal congestion, and itchy, watery eyes. These symptoms gradually subsided with subsequent exposure during the short lunar stays for most crewmembers and CMPs upon return of the lunar walkers to the CM. One Apollo astronaut recommended, "Adding a non-sedating antihistamine like Claritin® to the med kit might help." One of the Apollo flight surgeons related a story of moderately severe upper respiratory symptoms due to lunar dust exposure when he unstowed the suits after landing. These symptoms worsened with each subsequent exposure. He noted moderate elevations of his total WBC count, primarily the eosinophil levels which are commonly associated with allergic reactions. It is important to note that he did not have pre-exposure baseline WBC counts done to document if the elevation was in fact due to the lunar dust exposure. Lunar dust, however, is not an allergen but a toxic irritant, so it is unlikely that a anti-histamine would work to ameliorate the upper respiratory symptoms. This area is currently under investigation by the Lunar Airborne Dust Toxicity Analysis Group (LADTAG).

38. ***Saline eye drops need to be available in large quantities* (however, an eyewash will be available as part of the environmental health kit*)**. The lunar dust was ubiquitous in the vehicle cabin, and was very difficult to clear from the hands. Cabin fiberglass was also a problem on some of the missions. In each case ocular irritation occurred that required copious saline irrigation to treat. The crews felt that plenty of saline eye drops should be available in the medical kit for both ocular and nasal irrigation.

39. *Provide items that are needed in daily life, e.g., nail clippers, lotions, Band-Aids, etc.* (Individual hygiene kit will be available). During medical debriefs, several crewmembers noted frustration at not having items used during the course of normal daily hygiene available in the on-board kits.

40. *Sufficient analgesia to treat headaches*. Headaches were frequently reported during the missions. Crews were concerned that they may be due to elevated cabin CO_2 levels since the monitoring devices were unreliable. Headaches are one of the symptoms of Space Adaptation Syndrome[20] and noted as one of the most frequently occurring symptom throughout the space program. Crews used acetaminophen or ibuprofen with improvement in symptoms. The recommendation was for a sufficient quantity to supply all astronauts for the duration of their mission.

41. *Sleep medication must promote restful sleep but not be too sedating*. The sleep medication used during Apollo, Seconal, was a barbiturate. Side effects included

excessive sedation and "hangover" effect, essentially drowsiness the day after a dose. Some lunar crews described sleep on the moon as "two hours of nodding off" but were reluctant to take the sleep medication because of the sedation effect. The sleep medications, currently used by U.S. astronauts on STS and ISS, are of a different drug class and generally much less sedating while promoting restful sleep.

42. ***An adequate delivery system for nasal decongestants must be available for the crewmembers***. Nasal congestion was experienced by most crewmembers, and was attributed to the 100% O_2 environment, dust, and viral exposures preflight. Actifed was used and provided moderate relief. Oxymetazoline (Afrin®), a topical decongestant, was unavailable for Apollo 7-13 due to packaging problems. Lunar crews stated that symptoms resolved on lunar surface after initial exposure to dust only to return when reentering the CM as the particulates floated throughout the cabin in microgravity.

4.5 Environmental Impacts

43. ***Consider adapting the Skylab waste management system into the new vehicles***. In general, the Apollo waste management system worked satisfactorily from an engineering standpoint. However, throughout the medical debriefs the crews reported that the system required ~45 minutes from start to finish for defecation. Crewmembers had to strip off underwear requiring BIOMED sensor removal, a time consuming process. Application of the Apollo bag was often difficult. One Apollo astronaut described the process as "a complete mess" and "the only part of the whole mission that made me feel uncivilized." Crews strongly recommended creating a device that would allow them to assume a squatting position to have a BM. The Skylab charcoal system was good for waste management as it provided both the ability for the crew to strap down to the toilet and assume the squatting position and a ventilation system that controlled odor.

However, off-nominal "output" such as loose stool or diarrhea is an issue not adequately addressed by either Apollo or Skylab systems. The urine collection system was "lousy" as the UCD frequently leaked. The crew was very concerned about voiding difficulties during critical operations. The urine bag, if used, created backpressure in the system, which contributed to one occurrence of in-flight urinary tract infection.

44. ***The sleep restraint system on the Apollo CM worked well and should be incorporated into the new vehicle design***. The straps used on the couches allowed the crewmembers to fasten securely within the sleeping bag. Some crewmembers found wedging themselves under the couches to be comfortable. The sleep system used in the LM was adequate for later Apollo missions, with a few members commenting that the hammock was very comfortable in 1/6 g. However, other factors impaired restful sleep (See Appendix G). A few crewmembers suggested that alternatives to the hammock system would have to be created for extended duration missions. One crewmember chose to sleep on the LM floor but found it very cold and dirty with lunar dust.

45. ***Sleeping bag needs to be large enough for crewmembers to get both knees to their chest***. The crewmembers often assumed a "fetal position" to treat low back pain and found it difficult, if not impossible, to bring both knees to their chest during sleep.

46. ***Thermal protective clothing or equipment should be available on board***. The Apollo 13 crews suffered hypothermia in the 39°F LM they used as a "lifeboat" during the contingency return. The EVA suits were available but they chose not wear them because of the difficulty stowing and unstowing items from storage compartments. The A13 CDR and LMP offered the recommendation that a simple, light, and effective thermal blanket should be available in contingency situations.

47. ***Drinking water should be available during sleep periods***. The CM and LM cabin was very dry prompting a frequent need to drink water, interrupting sleep. The astronauts suggested having a water bottle available next to the couch or in the sleeping bag.

48. ***Hot water capability for hygiene, beverage, and food preparation is essential***. The astronauts felt very strongly that having the capability to heat water for routine daily dietary and hygiene use was a necessity. Cold water would be nice to have, but hot water was required. This was a position they felt was not negotiable.

49. ***Apollo bag aperture and capacity needs to be larger and easier to apply in microgravity***. The Apollo bag was a bag that crewmembers passed stool into. Crews unanimously stated that the Apollo bag aperture was too small and the application was very difficult in microgravity. A better system has to be developed for future crews.

50. ***Create a device that would allow crewmembers to assume a squatting position in microgravity***. The crews summed it up well with this statement: "Try pooping standing up with a bag stuck to your butt and see how you like it. Engineers will have to do a better job in the waste management design on future vehicles."

51. ***Do not design the galley and waste management areas together***. The reason for this recommendation should be obvious but the Apollo galley and waste management area were designed within a foot of each other. The crews frequently had diminished appetites for other reasons and did not need the added effect of odor and mess to further compromise their nutritional intake.

52. ***Minimize noise but do not eliminate it*** **(earplugs are an adequate countermeasure for noise)**. Noise was an issue for sleep, especially on the LM, but was comforting to the crew. Non-essential communications from the Mission Control Center (MCC) were annoying and need to be eliminated during the sleep period. Simple ear plugs work well and more elaborate systems are not necessary. As an aside, in the LM sunlight was blocked with shades to aid in restful sleep.

53. ***Carbon dioxide*** **(CO_2)** ***monitoring device needs to be robust and reliable***. The CO_2 monitor was frequently malfunctioning with resultant unreliable sensor readings. Crews often remarked they had headaches during the missions, one of the initial symptoms associated with elevated CO_2 levels. The faulty sensor system made it difficult to attribute

the crew's symptoms to elevated CO_2 levels in the cabin. This problem persists today on the STS and ISS with crews frequently reporting headaches.

54. ***A food warmer is desirable***.

55. ***Astronaut participation in the design and development phases of the new vehicles is essential***. The Apollo astronauts were intimately involved with the requirement development phase through vehicle assembly. Many attributed their mission success to their knowledge of the vehicle systems and hardware. Astronauts associated with the new vehicles should be involved with all phases of its development.

56. ***RFID tags should be considered for stowage items***. Radio-frequency identification (RFID) systems are well established in organizing stowage and retrieval of equipment and other mission gear. This system would provide a reliable tool to locate items within the stowage compartments of the new vehicles and track consumables usage.

57. ***LSAM windows should be designed to see only what is necessary for landing and/or rendezvous with IR protection***. Windows are heavy components of the vehicle and should be designed with these requirements to minimize their mass. Crews will require adequate protection from IR radiation exposure.

58. ***Design an efficient method for clearing the lunar dust from the vehicle cabin***. Lunar dust particles floated everywhere in the LM upon return to microgravity. Dust particles floated into crewmembers eyes, nose, and lungs, which prompted the Apollo 12 crew to keep their helmets on prior to docking with CSM. The dust did not appear to be filtered from the environment through ventilation/LiOH system although the vacuum cleaner that was used beginning with Apollo 14 seemed to help clear the larger particles.

4.6 Radiation

59. ***The lunar excursion vehicle should have an active radiation detector with an automated audible alarm that sounds when the dose rate exceeds a predetermined level***. The Apollo mission plan for a radiation event on the lunar surface was based on incorrect assumptions. The assumption was that after Earth-orbiting satellites detected the initial x-rays, the crews had between 15-20 hours before the solar protons arrived at the moon[25]. During this time the crews would be directed to make the traverse back across the lunar terrain from the worksite to the LM, prepare the vehicle and launch off the surface, successfully rendezvous with the CM, dock and secure the hatch, transfer to the CM, and rotate the vehicle so that the thicker side of the vehicle faced the sun thereby absorbing the radiation. Apollo crews did not have an active radiation detection and alarm system on the lunar surface. Recently (2005), a solar event occurred where energetic protons arrived at Earth within 5-20 minutes of the original x-ray detection. (Note: We also have more information about the directionality of solar protons which suggests crews should not launch from the lunar surface during a solar particle event.) Obviously, the Apollo response requires reconsideration. The crews were adamant that the lunar return crews have the capability to detect hazardous radiation levels. The EVA

suit, rover, and habitat should have the capability to provide autonomous detection and immediate response countermeasures should be embedded in these systems.

60. ***A personal radiation dosimeter (PRD) is a requirement for all crewmembers***. Although this was a requirement for all crewmembers, some of the Apollo crewmembers neglected to wear the device in the suit during lunar surface operations. They recommended designing it into the suit garments thereby eliminating the possibility that it would be left behind.

61. ***The rover should be equipped with a radiation shield***. A durable and effective shield for solar protons should be available for crews on the lunar vehicle for a solar particle event.

62. ***Radiation protectants should be made available to the crewmembers***. Recent developments in radioprotectants suggest that they may be useful to mitigate the risk of developing radiation sickness in crews exposed to solar radiation. The Apollo astronauts stated that they would consider using such compounds if exposed to radiation while on the lunar surface.

63. ***Create a trench with shovels or explosives to protect the crew short term in the event of a solar particle event***. For radiation protection on the surface, creating a trench with shovels or explosives would be adequate to protect the crew short term. It is important to cover the trench quickly with regolith. A real-time active PRD in the suit will let you know how well you have done with regards to exposure and when it would be safe to leave the site. In-suit consumable recharge capability would have to be available also.

4.7 Performance/Human Factors

64. ***Recreational activities need to be made available for crews during trans lunar coast* (TLC) *and trans Earth coast* (TEC)**. Trans-lunar and Trans-Earth coast were relatively "*boring*," however, this was an individual experience. Crew wish they had brought recreation materials. Apollo CMPs remarked that the CDR/LMP could relax but he was always on task during this [TLC/TEC] mission phase. Crewmembers reported that they liked having the non-work related time during TLC and TEC, but wanted recreational activities available during this time. Exercise was one of the most desirable activities during this mission phase. This was also important for the CMP during lunar surface operations. Apollo crews recommended for long-duration missions within the constraints of the vehicle "*make the space vehicle environment as normal as it is down on Earth.*" The CEV should be as autonomous as possible. Several of the CMPs stated that it was difficult at times to stay focused during lunar surface operations. Air-to-ground communications helped tremendously. MSFN relay was the best thing CMP had during this time. Other activities included watching the local news to make the day more similar to Earth. Delegation of routine operational "chores" and flight plan maintenance to the MCC would free the CMP to do non-work related activities, such as lunar or deep space

photography. The A15 CMP stated he used this time to explore deep space while on the far side of the moon.

65. ***Mental and physical rest plans should be introduced into extended moon stays to allow adequate rest between lunar EVA***. Apollo astronauts stated, "*Consider mental and physical fatigue here separately. Although there was not a lot of physical fatigue* [during the lunar activity], *the mind was being used quite a bit. You can sometimes wear your brain out before your body is fatigued*."

66. ***Mission focus should be project-oriented and not timelined***. The Apollo lunar surface crews lamented that the timeline on the moon was very ambitious leaving little room for completing tasks in the event things did not go as planned. Future timelines should not be rushed and should allow crews to complete projects thereby minimizing error and potential injuries. A non-EVA suit related injury did occur during one mission that was a result of the astronaut trying to complete a timelined activity with a malfunctioning piece of equipment. The injury required the crewmember to use an excessive amount of analgesics for pain.

67. ***Use of sleeping medication should be encouraged where appropriate***. The crews were generally reluctant to use sleep medication because of the side effects previously described. "*There was always the fear of not being alert if an emergency came up. This can't work for long duration stays*." A number of astronauts also felt that use of sleep medication would be perceived among their peers and ground controllers as a sign of "weakness" and chose not to use the medication despite suffering insomnia (refer to # 41).

68. ***Countermeasures to combat mental fatigue are necessary throughout the mission***. Mental fatigue pre-launch was due to the amount of non-essential training [that was not operationally oriented]. There was too much last minute emergency procedure training just prior to launch. They suggested more "normal procedure" training and less emergency procedures training during this time period. Additionally, they suggested slowing the pace of training within 1-2 weeks prior to launch. They all launched fatigued. Preflight quarantine is very valuable as it allows time for simulation training, exercise, and rest. The crew schedule should have "*slack early in the mission to allow time for learning/training*."

69. ***Education and psychological services should be available to the crewmembers' families***. The crews commented that NASA should be more sensitive to the families needs than they were during Apollo. Family counseling was rejected by NASA when the crewmembers requested it. The crews were relieved to hear that the policy toward family psychological services within NASA has changed since their missions took place and that these services are provided.

70. ***Allow adequate time in the schedule for all activities***. In designing future mission scenarios, the following are recommendations for optimizing operational success and crew health: allow adequate time to practice mission activities in a variety of environments where tasks are defined and duplicated just like on the moon; allow time for all

activities such as eating, resting, exercise, experiments, etc. This will take coordination with the mission planners, and is especially important to allow enough time for meals. However, the astronauts were quick to point out that during certain mission phases, such as rendezvous and docking, adequate time may not be available for these activities.

71. ***Provide adequate capabilities for sleeping on the lunar surface***. Refer to the environmental section. The lunar crewmembers cited three environmental factors that impaired their ability to get restful sleep: light penetration into the vehicle, loud ambient noise level, and cool cabin temperature (particularly near the floor of the LM). Planners for the LSAM and future lunar habitat will have to correct these factors in addition to the aforementioned requirement for short-acting, well-tolerated sleep medication that does not cause excessive sedation or hangover effect. In addition, the sleep facilities will have to take into account the factors mentioned in the environmental section. In addition, the EVA suit did not provide comfortable sleep on the lunar surface. The inability to get restful sleep on the moon [because of the suit] "could have jeopardized the mission."

72. ***If a crewmember dies during the mission "cut him loose."*** Death of a crewmember during a mission is straightforward: "*If a crewmember dies, you cut him loose. You can depressurize the hatch and dump him*." "*Yes, if it happens, it happens…No psycho babble here*." The crews emphasized that trying to retain or recover a deceased astronaut could put the other crewmembers at risk. This plan would require working out the details far in advance of the mission so that all individuals involved, including the astronaut family members, would be prepared in the event this happened during a mission.

73. ***In planning crew size/makeup, the authority structure is much more significant than crew size***. This recommendation arose out of questions pertaining to the makeup of future exploration crews with regard to number of crewmembers, male/female ratios, etc. The Apollo astronauts were unified in their recommendation to emphasize that crew make-up requirements are secondary to the crew authority structure, i.e., the commander is in charge under all circumstances. Nearly all of the Apollo astronauts were military trained and understood authority structure. This was never more evident than during Apollo 13. The crew supported their commander and insured that he was given whatever was necessary to make the correct decisions during the mission rather than trying to usurp his authority over concerns he might be succumbing to fatigue or stress. Bottom line with crew size/makeup is to make sure they understand who is in charge. The other issues are of less importance.

74. ***Consider the impact on the mission control flight teams and take actions to ensure that they are rested and provided for during the lunar missions***. The crewmembers were sensitive to the demands made on the flight control teams and their families that resulted from planning and carrying out a lunar mission. They urge that NASA take necessary steps to support these individuals and their families during all phases of the mission. This included allowing enough time for sleep, family time, and training prior to and during the mission. The impact of the workload on mission control support personnel is a factor. In addition, they need defined sleep periods and time off to keep the mission functioning.

4.8 Crew Schedule

75. ***Preflight quarantine is very valuable for providing time for mission simulation, exercise, and rest***. From an operational point of view, it removed a large number of distractions from the last three weeks of preparations and the crews were much more rested for launch.

76. ***The preflight training schedule should allow crews to concentrate on issues that will be used for the nominal mission***. The crews wanted only mission related activities, such as simulator training and safety briefings, to occupy their time during the month prior to launch. Activities outside of training, such as exercise and rest, were often compromised during this time and should be as high a priority as any other training issue.

77. ***Lunar crews should have one day per week for "rest"*** **(freedom to select their activity)**. During the lunar surface stay, crews should have a scheduled day of rest during each seven-day period. This day would not have timelined activities but could be used at the crew's discretion. The Apollo astronauts emphasized that for extended duration operations, the crew will burn out if they do not have protected rest time during the week.

78. ***An eight hour per day sleep period must be protected in the daily schedule and must not be compromised***. Crew rest time was often the subject of compromise in the daily timeline, as it is today. However, the crew strongly encouraged the flight surgeons to protect the sleep period regardless of whether the crew actually slept. Circadian rhythm was considered not to have been an issue on lunar expeditions. Regarding sleep shifting, it was not optimum to have large shifts in short periods of time. Also, the Schumann Resonance Frequency must be considered. Crews suggested discussions with experts to evaluate the risk factor influencing sleep cycles once the crew is out of the Earth's geomagnetosphere.

79. ***Crews should be scheduled for simultaneous sleep periods.*** The initial Apollo missions had staggered crew sleep periods but were later changed to accommodate all crewmembers. This practice should be continued with the lunar return missions.

4.9 Exercise

80. ***Loosen the pre-mission timeline to allow adequate time for preflight conditioning program***. The astronauts recognized the importance of maintaining musculoskeletal strength and stamina prior to their mission and felt that time should be set aside during the pre-flight phase to exercise. This was noted to be particularly important to some of the lunar crewmembers who attributed their ability to operate the surface drilling equipment to an aggressive pre-flight upper body strength training program.

81. ***A more robust (and lightweight) piece of in-flight exercise equipment is needed than the Apollo Exer-Genie***. This device was the only exercise equipment available during the Apollo missions and was used by all crewmembers with varying amounts and intensities. A major limitation of the Exer-Genie was the friability of the ropes that connected to the cylinder that provided resistance and the heat that was generated with its

use. The Apollo CM atmosphere was 100% O_2 and there was a real concern that the heat generated represented a fire hazard. The crews used the device at sub-maximal levels to reduce heat generation. One crewmember stated that the rope and material "*frays and kinda smells*" after prolonged use.

82. ***The flight surgeon/mission planners should not plan specific exercise prescriptions for short duration* (< 14 days) *mission***. The crews performed exercise for rest and relaxation purposes as much as for the physical benefit. They cautioned the flight surgeons against trying to timeline specific exercises. They felt the crews should be instructed on what exercise would be beneficial and applicable for the device available, choosing what they wanted to do during short duration missions.

83. ***Exercise is not necessary on short trips* (14 days or less) [from a fitness standpoint], *however, crews demanded that the capability be available and varied as much as possible for crew "rest and relaxation" in all phases of the mission***. The crews did not feel that they suffered noticeable deconditioning during their relatively short missions. However, they do not dispute the science that shows muscle and bone strength decrements with longer microgravity exposures. In the context of their short missions and lunar EVAs, they were able to perform all mission related activities without concern from loss of strength or stamina. The astronauts demanded exercise capability for the CM for rest and relaxation purposes. A couple of crewmembers also experienced minor Achilles tendonitis after return to Earth and suggested that a more aggressive lower extremity stretching program enroute to home may have prevented this occurrence. The lunar surface crews felt that their activities on the moon provided enough exercise for a short duration mission but would have welcomed a simple, robust device for stretching and forearm strengthening exercise.

84. ***Develop a better preflight and in-flight forearm muscle-conditioning program for lunar crewmembers***. In addition to the core stabilization program as described earlier in the illness/injury section, a strengthening program for the forearm muscles before and during the mission is necessary. Upper extremity exercises, specifically to strengthen and maintain shoulder strength and stamina, will be necessary in the preflight period and during the mission. As mentioned previously, operating the surface tools in partial gravity, particularly the drill, requires more force generated from the shoulders than needed in 1 g.

85. ***New vehicle design should allow a variety of different exercise capabilities* (hardware vs. cabin structure)**. The astronauts recommended examining the new spacecraft design to determine surfaces or structures within the vehicle to exercise various muscle groups. Also, a more robust (and lightweight) piece of equipment is needed. The crews performed isotonic exercises against the struts of the LM on the surface before EVAs. Another example of using the vehicle in novel ways to perform exercise included "running in place holding onto the couch," isometrics performed against cabin structures, etc.

86. ***Put as many*** **[exercise]** ***capabilities in the vehicle as possible, because it will get used***. Many crewmembers felt exercise capability throughout flight will be critical. A variety of exercises must be provided.

87. ***New exercise devices should be reliable, simple, and not develop excessive heat in use***. The crew was concerned towards the end of the mission that they were going to "break the machine" and began tapering down the exercise duration and intensity to protect the equipment so that it would be available for reconditioning prior to re-entry.

4.10 Food/Nutrition

88. ***Mission activity*** **(e.g., coast, rendezvous, lunar orbit, lunar OPS, etc.)** ***will dictate what type and how much food will be consumed***. Apollo diets offered 2100-2660 kcal/day, but the crews seldom obtained these required energy intakes. During busy mission phases, the crews often went without eating or drinking because of issues with preparing food or problems associated with the water system. They recommended that meal planners work with mission planners to coordinate easily accessible food that could be prepared quickly to ensure that crew energy needs are met throughout all mission phases. Specific examples of mission activity and appropriate food types include:

- High activity – wet packages, bite-sized snacks, canned foods
- Low activity – spoon-bowls, dry juice or meals (rehydratable) requiring mixing etc.

89. ***Plain water in large quantities needs to be available for lunar EVA***. The crewmembers stated that they needed more plain water available for LEVA. As was mentioned in the EVA suit and Lunar Surface Operations section, the lunar crews often went 10 hours without a break after suiting up.

90. ***Optimize diet and food intake for overall performance during long duration missions***.

91. ***An in-suit non-caffeinated solid or liquid carbohydrate food source for lunar EVA would be helpful***.

92. ***Design adequate space and useful area in the new vehicles to store food packs during meals***. Lack of available space and useful area to store food packs during meals made eating difficult. Food preparers need to be mindful of the difficulties associated with performing tasks in microgravity.

93. ***Spicy and salty foods are preferred items in the menu***. Overall, the food lacked flavor or spice. Crews preferred the salty bite-sized snacks or other flavorful items as their taste perception changed in space compared to the preflight food testing.

94. ***Allow adequate time in the daily schedule for meals***. Refer to comments in recommendation # 88.

95. ***Determine how different environmental factors*** **(e.g., O_2 concentration, cabin pressure)** ***effect food flavor***. Foods tested preflight tasted fine but were "absolutely unattractive in-flight." One crewmember who had flown both an Apollo and STS mission stated he had a poor experience with food during Apollo but the same food flown on shuttle was palatable and tasty. His experience raised the question of the effect of the 5.0 psia and 100% O_2 atmosphere of Apollo on food integrity or taste perception compared to the 14.7 psia and 21% O_2 of the space shuttle. The future vehicles have a proposed cabin atmosphere of 7.6-8.0 psia at 30-32% O_2.

4.11 Launch/Landing/Recovery Operations

96. ***Provide adequate cooling capabilities for the crew on landing to mitigate the hot cabin contribution to crewmember seasickness***. Considerable weight loss was attributed to sweating and dehydration that occurred on landing secondary to seasickness. Inadequate cabin/suit cooling after landing was cited as the primary contributor to both conditions. The future landing vehicle must have adequate cooling capabilities for the crews. The onset and severity of seasickness will be determined by the crew's ability to stay cool more than anything else.

97. ***Ground landings are discouraged***. This was not a consensus statement among the crewmembers. A number of the Apollo astronauts, however, were adamant that a ground landing would likely kill the crewmembers. NASA has considerable experience with water landing, have never lost a crew by landing in the sea, and have a much larger margin of error for re-entry. Ground landings do not afford much error and may pose a threat to humans in populated areas with an off-trajectory re-entry profile. The dissenting Apollo astronauts, however, mentioned that we now have extensive experience via the shuttle with ground landings, and that perhaps water landings could be used to build confidence before moving forward with ground landings. It was also pointed out that the navigation capabilities to track the re-entering spacecraft were not well-developed or reliable whereas the navigation systems today are a proven technology and would ensure reliable land trajectories upon reentry.

98. ***Apollo seat configuration for water landings was adequate***. The seats were adequate for re-entry despite force distributed throughout body. Impact was well distributed across the back. Couches and restraints were adequate for landing and launching from the Earth and moon in terms of side and head protection. All loose items need to be restrained; one crewmember sustained a scalp laceration after being struck in the head by an object that came loose when the capsule impacted the water.

99. ***Medication for motion sickness and fatigue should be available prior to re-entry***. Scopolamine 0.3 mg/Dexedrine 5 mg were taken by several crewmembers prior to re-entry and again at splashdown to prevent motion sickness and to combat fatigue.

100. ***Sea state should be limited to < 6-8 foot swells if recovery is to be delayed***. Most of the Apollo astronauts were naval aviators or experienced pilots with one exception. Nearly all the astronauts experienced seasickness, some reporting the onset of symptoms

within 30-60 seconds of the water landing. The crews strongly recommended that the recovery sea state be limited to less than 6-8 foot seas.

101. ***Have food and plain water within reach of buckled crewmembers for delayed recovery***. Dehydration was a significant concern due to lack of suit or cabin cooling. Food and plain water will need to be readily available for the crews in sufficient amounts to sustain the crew until recovery teams can remove crew from the landing capsule.

102. ***Apollo CM hatch location and size was adequate for egress***. Hatch location for landing egress was adequate. Apollo crewmembers denied having any trouble emerging from the capsule after landing. The crews offered a mixed response as to whether they would have been able to assist an injured crewmember in an emergency scenario. Crewmembers also recommended that the hatch on the re-entry vehicle open outward in response to the Apollo 204 hatch that opened inwardly preventing crew escape during the fire. However they pointed out that a hatch design that opens outward but does not seal with pressure is very dangerous, referring to the potential for cabin atmosphere leaks

103. ***All control panels and switches should be within reach of crewmembers during launch and landing***. Regarding the control panels and switches, all required functions were within reach during high g and zero g in the Apollo CM. This was tested in centrifuge runs in the design and development phase. The same approach should be taken for the new launch and return vehicle.

104. ***Training for pad abort was adequate and should be continued***. The slide wire abort works. One crewmember felt the egress route under the pad room in Apollo provided a faster and safer escape route than the slide wire.

105. ***Crew surgeon should be on the recovery vessel and not the helicopter***. The rescue crew provides all the necessary skills for safely transferring the crew from the vehicle to the helicopter. The crew flight surgeon serves his/her purpose best on the recovery ship and should not be put at risk in the recovery aircraft.

4.12 Flight Surgeon-Crew Interaction

106. ***Crews encouraged the Flight Surgeon to "act as more of an advocate of the crew" than treat them as an experiment***. Crews often felt the flight surgeon treated them as "*an experiment*" considering the demands the flight plan placed on them. Lack of PMC with flight surgeon limited the crew input regarding physiological functions and medication usage during flight. After one CMP was left hanging regarding his flight status due to an abnormal lab value 3 weeks prior to launch, the CDR and CMP both felt the flight surgeon was not looking out for the crew's "mental well being." The CDR emphasized that "emotional stress is one of the main issues [that the flight surgeon] needs to help minimize both preflight and in-flight for his/her crew." A number of crewmembers did state instances where their individual flight surgeon supported them above and beyond the call of duty and were grateful for their dedication to their crews.

107. ***The collaboration established between the current flight surgeons and Apollo crewmembers should continue and be an example to future generations***.

5.0 DISCUSSION

The purpose of this study was to identify Apollo operational issues that impacted crew health and performance. The specific goals of this project were to develop or modify medical requirements for new vehicles and habitats, to create a centralized database for future access, and to share relevant Apollo information with the multitude of entities at NASA and abroad participating in the exploration effort. Secondary objectives included using this information to validate current requirements and refresh knowledge regarding lunar operations. The database has been created to complete this study, and the information gleaned is currently being shared among NASA entities. What remains is to discuss the modification of exploration medical requirements based on the experiences of the Apollo astronauts.

The only experience that the human race has with manned lunar exploration is through the perceptions and memories of the 22 surviving Apollo astronauts. As such, their experience and knowledge is a vast resource that has been surprisingly untapped. This paper has attempted to extract and archive this resource. Underlying everything from the abstract to the conclusion was the ethos of "operationally driven outcomes." In other words, the focus was to determine how the positive and negative experiences of the Apollo astronauts can improve the mission operations of the Constellation crews. The authors diligently focused on extracting that which had potential operational relevance, so that the varied audience could come away from the paper with something tangible to incorporate into their exploration work. Also, as discussed in the Methods section, previous published data was exhaustively researched to prevent duplication of results and conclusions. Topics currently under investigation by NASA research groups, such as lunar dust, or systems that will most likely not be used in future vehicle designs, such as the Apollo biomedical sensors or chlorinated potable water system, although important, were not specifically addressed in this study. Further, data contained within this paper has been reviewed for accuracy by the Apollo astronauts. Hence, the results are an attempt to achieve an untainted representation of the thoughts and recommendations of the Apollo astronauts themselves. The authors of the paper have simply acted as the "middle-men."

There are both strengths and limitations of the ability of these results to "develop or modify medical requirements for new vehicles and habitats." Are these events and challenges that occurred over 35 years ago applicable today? On Apollo missions, the astronauts were allowed to bring one cassette tape into space for morale purposes. Today astronauts can carry an Ipod® with 80 Gigabytes and 20,000 songs. True, there are now new paradigms and new technologies, however, the authors (and the Apollo astronauts) feel that those who don't learn from history are bound to repeat it. Just as Sun Tzu's "Art of War" is as true and applicable today as it was in the 6th century B.C., the lessons of the Apollo astronauts will find significance and relevance with future exploration missions. Limitations inherent to this study potentially include non-response bias and the volunteer

effect, procedure bias, and recall bias. Also, there are limitations to the applicability of the 107 recommendations, some recommendations are “more relevant” than others. For example, there were many recommendations regarding the waste management system. Many of these issues have been vastly improved through years of shuttle and space station experience. These recommendations are somewhat “less relevant.” However, in general, the recommendations in the categories of EMU/EVA Suit Operations, Lunar Surface Operations, and Lunar Radiation are “more relevant” due to the fact that they are related more closely to lunar exploration and have not yet been duplicated or improved upon. In the end, the relevance of each recommendation must be considered carefully and individually.

The principle findings of this study can be broken down into broad pervasive themes and themes relevant to each of the 11 recommendation categories and subcategories. Three themes were ubiquitous throughout the project. The first two, safety and mission accomplishment, were explicit and self-evident. These two ideas are intertwined, virtually impossible to separate, and at the core of every recommendation that was put forth. The third ever-present, but almost “unconscious” theme was one of human factors, and in particular, the idea that “the astronauts are only human.” When analyzing the responses one gets the idea that the astronauts are imploring the establishment to acknowledge that they are humans, not robots or test subjects. This was evident with multiple recommendations spanning the 11 categories. For example, scheduling-related recommendations were made in 4 of the categories for a total of 23 recommendations. Likewise, 10 sleep-related recommendations were made in 3 categories and more generally, ~26 recommendations for “rest and relaxation” were mentioned in 6 categories. Further evidence for the recognition of their limitations includes multiple recommendations for ensuring adequate “self-maintenance” via exercise, nutrition and fluid intake, and a higher level of waste and personal hygiene. Finally, the astronauts made multiple recommendations (7 in 6 categories) and requests regarding Flight Surgeon/Physician advocacy and intervention. Military pilots traditionally have had an apprehensive relationship with Flight Surgeons, hence the astronauts’ appeal to seek assistance from someone who could potentially ground them should be considered significant. They even went so far as to unanimously recommend the addition of a physician-astronaut as a crewmember, with the thought being that a physician-astronaut would increase the comfort level among the crew, and could serve as a strong advocate for astronaut needs while in space. A final observation worth mentioning is that the astronauts’ recommendations were very difficult to categorize. That is, a single recommendation such as “Improve glove flexibility, dexterity and fit, simultaneously involves operations, engineering, human factors, safety, and mission accomplishment. This brought to the forefront the uniquely interdisciplinary nature of manned space exploration and the broad appeal of this paper.

The Tables 3 through 14 list the Apollo astronauts' 107 recommendations followed by the current status and disposition of that recommendation. The status definitions are as follows:

In Practice	The recommendation is operational in current shuttle and ISS missions
New Requirement	The listed requirement was created as a direct result of the Apollo recommendations
Requirement Modified	The listed requirement was revised as a result of the Apollo recommendations
Requirement Validated	The listed requirement was validated by the Apollo recommendations
OpsCon Validated	The listed operational concept was validated by the Apollo recommendations
Being Evaluated	The recommendation is actively being analyzed for future requirements
Consider	The recommendation is known by involved parties, but there is no formal review for acceptance or rejection
Rejected	The recommendation has been evaluated and subsequently rejected as a requirement

The emphasis of the recommendations varied through each of the 11 categories:

EMU/EVA ISSUES

EMU/EVA recommendations centered first and foremost on improving the functionality of the suit first and foremost and then focused on improving both the human factors integration as well as specific safety features. The most adamant of the suit recommendations and a consensus statement was to improve the dexterity of the glove. This recommendation had mission accomplishment and safety as the driving concerns. Similarly, the astronauts recommended increasing ambulatory and functional capability through increased suit flexibility and decreased mass and internal pressure. Theoretically this will have the added benefit of decreasing fatigue as well. The human factors recommendations revolved around consumables and excretion. They recommended in-suit access to large amounts of high energy liquids and plain water, a Heads-up Display with consumable, biomedical, and navigation information on demand, and an improved urinary collection system. Safety concerns revolved around redundancy being built into the suit. In particular, they suggested a system to prevent helmet fogging under all circumstances, a self-sealing pressure garment in case of puncture, and a system to protect the zipper from abrasive lunar dust.

Spacesuit technology has improved over the years through shuttle and ISS experience, however, only the Apollo astronauts have the experience of operating in the lunar environment at 1/6 gravity. As such, their insight is very relevant to exploration requirements.

As can be seen in the Table 3, the EVA Systems Project (ESP) and the Human Research Program (HRP) via the EVA Physiology Systems and Performance (EPSP) element is quite active with this set of Apollo recommendations. The EPSP and ESP is aggressively evaluating multiple recommendations and considering several others. EPSP has a systematic test plan that will address suit related issues and result in specific data backed recommendations for the optimal suit weight, mass, pressure, center of gravity, and kinematics (mobility) for lunar operations. Additionally, the EPSP and Exploration Medical Capability (ExMC) team have addressed the UCD issues and have developed improvements to the Maximum Absorbent Garment (MAG).

Table 3: EMU/EVA Issues Recommendation Implementation

Cat	#		Apollo Recommendation Summary	Status	Disposition	Reference
Functionality	1		Improve glove flexibility, dexterity, fit			
		a)	Gloves should be custom designed for each crewmember that incorporate mechanical closure for gripping	Being Evaluated	Being Evaluated for CxCP, Eval per ESP/EPSP. To be documented in Element Requirements Document (ERD)	
				In Practice	Already in practice for flight gloves	
		b)	Look into a wrist seal and depressurized glove	Consider	Will consider with counter pressure suit concept	
		c)	Robotic power-assisted glove for repetitive tasks	Consider	Will consider in design for planetary suit configuration	
		d)	Glove liners should be worn	Being Evaluated	Already in practice for ISS suit. To be documented in Element Requirements Document (ERD)	
	2		Reduce the mass of the suit by a factor of two	Being Evaluated	Suit mass trades being evaluated by ESP/EPSP and suit engineers	
	3		Increase general mobility by a factor of four, primarily at the knee joint	Consider	Suit mobility requirements being defined by ESP/EPSP	
	4		Lower suit Center of Gravity	Being Evaluated	C.G. trades being evaluated by ESP/EPSP	
	6		Improve peripheral vision by adding neck ring (movable joint)	Being Evaluated	Trade between mobility vs. potential for landing injury due to a hard ring, evaluation by ESP/EPSP; TBD in EVA Architecture Description Document.	
	8		The lunar boot functioned well and does not need to be improved.	Requirement Validated	Suit trauma eval per EPSP	
	12		The suit should be a low pressure (3.50 psia), single gas system	New Requirement	Requirement in HSIR- variable pressure suit 3.5-8.0 psi; 100% O_2; Suit pressure trades being evaluated by EPSP	HS3005
Human Factors	7		Develop a reliable Heads Up Display that shows consumables information, limited biomedical data, and navigation on demand	New Requirement	Display requirement in HSIR for planetary suit. Implementation TBD for HUD vs. voice activated being evaluated by ESP/EPSP	HSIR Section 3.6.4.1
	10		The drink bag should have capability to contain a high energy liquid in addition to plain water	Being Evaluated	Requirement under consideration for planetary suit	
	11		Develop a better in-suit Urine Collection Device that will work in 1/6 g	Being Evaluated	Specification for MAG will include improved interface. Additional details currently TBD, being evaluated by ExMC and ESP/EPSP. To be documented in Element Requirements Document (ERD)	
Safety	5		Develop a system that prevents helmet fogging during heavy exertion	Consider	Consider Helmet ventilation specified in D&C to prevent fogging; being evaluated by ESP/EPSP	
	9		Use a self-sealing pressure garment within the suit for puncture	Consider	Consider HSIR requirement for DCS risk reduction and materials selection suit requirements; being evaluated by suit engineers and ESP/EPSP	
	13		Protect the suit zipper function	Consider	Consider in suit requirements	

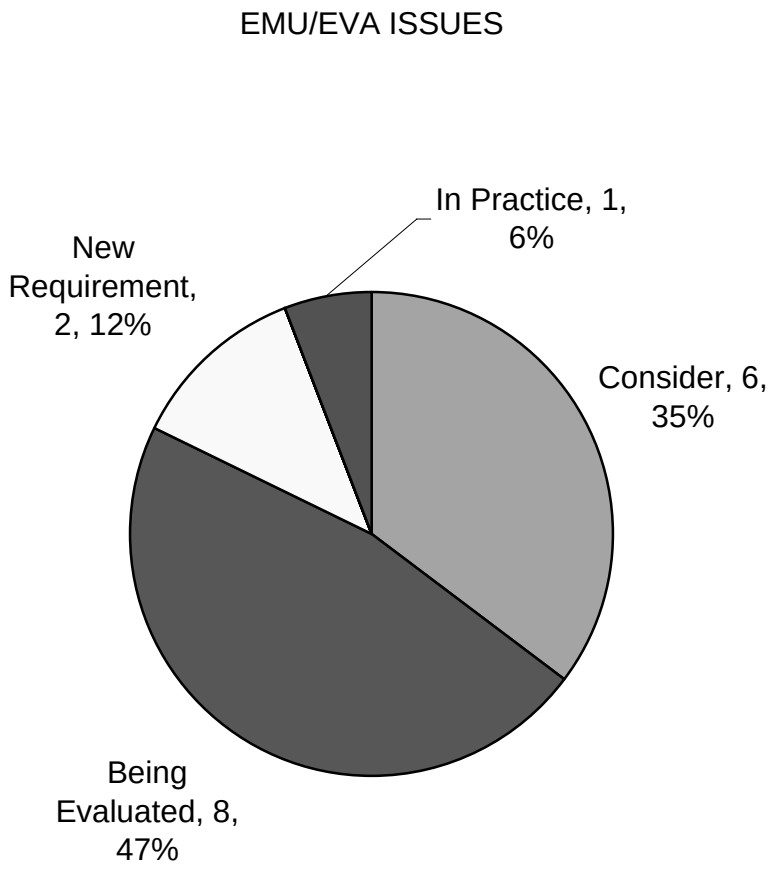

Figure 2. EMU/EVA Issues

LUNAR SURFACE OPERATIONS

Recommendations for lunar surface operations revolve around human factors, safety, and operational efficiency. Human factors and safety considerations were particularly intertwined in this category. A recurrent comment by the Apollo astronauts about operations on the lunar surface was an overwhelmingly packed schedule. For extended operations, the astronauts were adamant about decreasing the workload in the schedule. They suggested a maximum of 2 LEVAs within a 3 day period and a schedule with flexibility and “breathing room” built into it. They also commented that surface operations could begin once operationally feasible, that LEVAs should be one continuous event with ample food and liquids available before and during the event, and that the schedule should be front-loaded to minimize error and injury. Major risks identified were falls, rover operations, and navigating slopes in excess of 20-26 degrees. With suit functionality improvement, some of the risks identified will be reduced, one example being upper extremity injuries due to inability to visualize placement of an outstretched

arm. To increase operational efficiency the astronauts recommended using HUD technology, robots for repetitive tasks, and the rover to recharge suits. They also felt that for extended operations, LSAM ingress and egress portals must be closely scrutinized. They emphasized with a consensus statement that the hatch size must comfortably accommodate pressurized suits and that engineers consider an airlock. In general, they felt that the familiarization training with partial gravity devices or aircraft, such as the POGO or parabolic flight, and analog training was sufficient.

The longest any of the astronauts spent on the moon was three days yet many of their recommendations inferred problem areas for extended lunar stays. Therefore, this category in particular is very relevant to future lunar exploration. Also, many of their recommendations are straight forward and difficult to counter. For example, guarding against overwork and ensuring food and water availability seems obvious, but implementation may not as straight forward during planning phases. Surprising recommendations included the astronauts' acknowledgement and requests for new technology (such as an iPod®) that one might have thought to be outside of the paradigms of these mostly 1960s and 70s era astronauts. Also, multiple recommendations have already been implemented by virtue of shuttle and ISS operations.

Table 4: Lunar Surface Operations Recommendation Implementation

Cat	#		Apollo Recommendation Summary	Status	Disposition	Reference
Human Factors	14		Schedule crews for two Lunar EVA days on and one day for maintenance, alternating crews throughout the week	Being Evaluated	LAT2 and ARDIG defining architecture; to be placed in Ops Con document	
	16		An airlock may make ingress/egress easier and will also be a good idea from a dust control standpoint	Requirement Validated	Requirement for Airlock in EARD and CARD; NESC/LADTAG advocating suitlock engineering solution for dust management.	CA0394
	22		Ensure adequate water and food are available before and during lunar EVA	Requirement Validated	Requirement in HSIR	HS6062
	26		Plan the operations on the surface so that you protect the crews from themselves	Consider	Will need Ground and Flight Rules to limit	
	28		A robot should perform routine, systematic, repetitive, menial tasks (may help prevent repetitive use injuries).	Consider	LAT2 surface focus element, ARDIG and EVA systems to consider	
Safety	17		Surface activities can begin once operationally feasible	OpsCon validated	Current Cx Ops Con maximizes surface tasks for crew during landing day	CxP 70007, Section 5.9
	19		Limit navigation into craters with a slope < 20 - 26º	Being Evaluated	ARDIG/Ops Con consideration; will need a Flight Rule, evaluated at planetary analog HMP 2006	
	21		Ladder rung height and width on the Lunar Module (LM) were good but the glove did not allow adequate grip for safety	Being Evaluated	Draft requirements in EVA D&C.	
	23		Lunar EVA should be performed as one continuous event	OpsCon validated	Ops Con, EVA Ops Con	
	24		Risk factors for injuries identified:	Consider	Consider at the level 3&4 SRDs and Flight Rules; being evaluated by ESP/EPSP and ECP	
		a)	Navigation into sloped terrain or craters with slopes > 20 - 26º			
		b)	Rover activities: CDR, LMP at risk for injury if not restrained			
		c)	Falling from a height. The rim of a crater, the ladder			
Operations	15		The hatch and ingress corridor should be sized appropriately for an inflated 1/6 g pressure suit	Requirement Validated	Validated but under threat of rejection, weight push backs are driving the hatch size closer and closer to absolute minimums; for LSAM ingress/egress must be easy; minimal hatch requirements being evaluated by ESP/EPSP	HS5004
	18		There is no special training needed for 1/6 g EVA's other than a familiarization session.	Consider	Lunar Crew Operations Training Plan, may use POGO or similar 1/6 g simulator- EPSP evaluating	
	20		Crews requested that an automatic position determination device be available to aid navigation on the lunar surface	Being Evaluated	EPSP evaluating navigation and position aids for surface EVA; consider for EVA system requirements document	
	25		To ensure operational success and optimize performance of the crews, allow adequate time to practice mission activities in a variety of environments including analogs that allow preparation for off-nominal events	In Practice	Planetary exploration Analog WS to be held in March, 2007; analog management by HQ and ARDIG	
	27		With extended ops on the moon, establish all the experiments in the first week.	Consider	Will need Ground Rules and put Expedition planning guidelines	
	29		The Rover should have the ability to recharge the suit	Being Evaluated	LAT2 Surface Ops Focus Element evaluating EVA Ops trades	

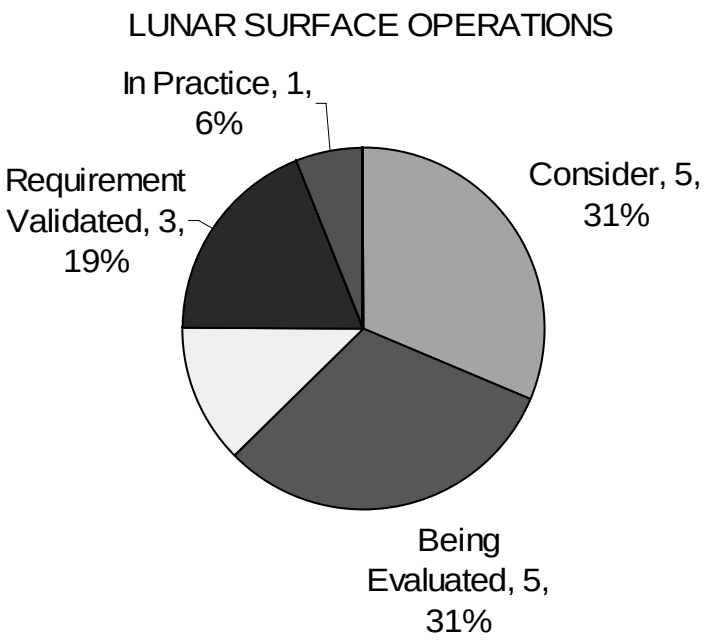

Figure 3. Lunar Surface Operations

IN-FLIGHT ILLNESSES

Recommendations addressing in-flight illness focused on pain, gastrointestinal dysfunction, and preventative screening. In particular, treatments or preventative measures were recommended for lower back and forearm pain and soreness, constipation and diarrhea, and heart disease. The two consensus statements in this category included therapy to relieve muscle soreness, especially in the forearms, and to include a physician crewmember to increase the comfort level among the crewmembers. This category also demonstrated the inter-disciplinary nature of space operations. For example, it was discovered that crewmembers intentionally constipated themselves with medications to reduce or completely prevent the need to use the poor waste management collection system. Another example is the forearm soreness. A well-designed glove would render this complaint a non-issue.

This category although significant, has less relevance due to improvements that have been implemented during Skylab, Shuttle, and ISS operations. All issues except the consensus related statement regarding a physician-astronaut are accounted for in Table 5.

Table 5: In-Flight Illness Recommendation Implementation

Cat	#		Apollo Recommendation Summary	Status	Disposition	Reference
Human Factors	30		Lower back pain should be treated with aggressive pre-mission and in-flight core strengthening program	Being Evaluated	Cx Medical Operation Requirements are in development	
	31		Therapy to relieve muscle soreness, primarily in the forearms, must be available (improved glove design may assist this)	Being Evaluated	Cx Medical Operation Requirements are in development	
	32		Constipation: improve the waste management collection system	Requirement Modified	Requirement for waste management in HSIR	HSIR section 3.5.3.2
	33		Screen for CAD prior to selection for lunar missions	Being Evaluated	Astronaut Medical Evaluation Requirements Document (AMERD) is being revised.	
	35		Adequate preventive measures and treatment for diarrhea must be available	Being Evaluated	Cx Medical Operation Requirements are in development	
Operations	34		A physician crewmember would increase the comfort level among the crewmembers and can be cross-trained to do other activities	Consider	Consider development of Crew selection guidelines for Lunar Outpost	

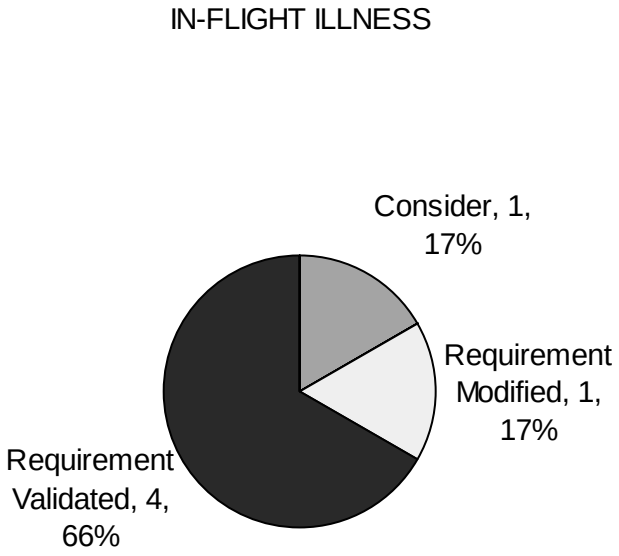

Figure 4. In-Flight Illness

MEDICATION/MEDICAL KITS

Recommendations focused on medications that would have improved operational efficiency and comfort. Recommendations for kit contents included allergy medications, saline eye drops, standard toiletries (nail clippers, lotions, etc.), headache analgesia, efficacious sleep medications, and an efficient decongestant delivery system. All of these items are currently accounted for or improved upon (i.e. eyewash is included in addition to saline drops) in the Constellation requirements.

Table 6: Medication/Medical Kits Recommendation Implementation

Cat	#		Apollo Recommendation Summary	Status	Disposition	Reference
Contents	36		A card in the medical kit to inform the crew of the medication duration, indication, and interaction with other meds is needed	Being Evaluated	Cx Medical Kit contents definition TBD	
	37		Add non-sedating antihistamines for allergy symptoms due to lunar dust exposure	Being Evaluated	Cx Medical Operation Requirements are in development	
	38		Saline eye drops need to be available in large quantities	Being Evaluated	Cx Medical Operation Requirements are in development (however, an eyewash will be available as part of the environmental health kit)	
	39		Provide items that are needed in daily life, e.g., nail clippers, lotions, band-aids, etc.	Being Evaluated	Flight Crew Equipment contents definition is TBD (individual hygiene kit will be available)	
	40		Sufficient analgesia to treat headaches	Being Evaluated	Cx Medical Operation Requirements are in development	
	41		Sleep medication must promote restful sleep but not be too sedating	Being Evaluated	Cx Medical Operation Requirements are in development	
	42		An adequate delivery system for nasal decongestants must be available for the crewmembers	Being Evaluated	Cx Medical Operation Requirements are in development	

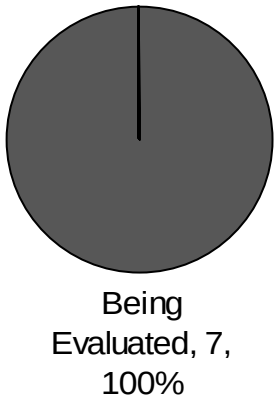

Figure 5. Medication/medical kits

ENVIRONMENTAL IMPACTS

Human factors and operational design were the two foci of the Environmental Impacts recommendations. Recommendations addressing human factors dealt with waste management, sleep, and consumables. The astronauts unanimously recommended the adaptation of the Skylab waste management system. They also wanted to see a device to allow for squatting for bowel movements, felt that the Apollo bag aperture and capacity both needed increasing, and would prefer that the galley and waste areas be separated. To foster restful sleep, the astronauts recommended minimizing environmental noise, having water available during sleep, increasing the sleeping bag size to allow for the "fetal position," and the incorporation of the CM sleep restraint system. Hot water capability was deemed essential and non-negotiable via a consensus statement. A food warmer was also considered desirable. Operational concerns centered on engineering redesign, a contingency input, and increasing efficiency. First and foremost, the crewmembers consensus was that astronaut participation in design and development is essential. Another consensus statement was to incorporate more reliable CO_2 monitors. They also felt that the LSAM windows should be as small as possible and that there should be a system for clearing lunar dust from the cabin. A consensus statement resulting from the experience of Apollo 13 was to include thermal protective gear in the event of a contingency. The last recommendation was to utilize RFID tags for stowage items.

The recommendations brought to light some points that would have been missed just as they were during Apollo. For example, as a result of the recommendations thermal

protection is being added to the crew equipment. Other changes and additions are shown in table 7.

Table 7: Environmental Impacts Recommendation Implementation

Cat	#		Apollo Recommendation Summary	Status	Disposition	Reference
Human Factors	43		Consider adapting the Skylab waste management system into the new vehicles	Consider	Waste Management System specification is in development	
	44		The sleep restraint system on the Apollo CM worked well and should be incorporated into the new vehicle design	Consider	Requirement for sleep accommodations in HSIR, details for Level 4 document TBD	HS6104
	45		Sleeping bag needs to be large enough for crewmembers to get both knees to their chest	Consider	Requirement for sleep in HSIR, details for sleeping bag are TBD	HS6104
	47		Portable drinking water should be available during sleep periods	Consider	Requirement for potable water in HSIR, the details for the portability of water will be in a lower level document	HS3025
	48		Hot water capability for hygiene, beverage and food preparation is essential	Requirement Validated	Requirement in HSIR	HS3031
	49		Apollo bag aperture and capacity needs to be larger and easier to apply in microgravity	Consider		
	50		Create a device that would allow crewmembers to assume a squatting position in microgravity	Consider	Waste Management System specification is in development	
	51		Do not design the galley and waste management areas together	Requirement Validated	Requirement for separation of galley and WCS in HSIR	HS6002
	52		Minimize noise but do not eliminate it (earplugs are an adequate countermeasure for noise)	Requirement Validated	Acoustics requirements in HSIR	HSIR section 3.2.6
	54		A food warmer is desirable	Requirement Validated	Requirement in HSIR	HS6003
Operations/Engineering	46		Thermal protective clothing or equipment should be available on board	Consider	Flight Crew Equipment contents definition	
	53		CO_2 monitoring device needs to be robust and reliable	Consider	Follow design of CO2 monitoring device	
	55		Astronaut participation in the design and development phases of the new vehicles is essential	In Practice	Currently in practice for Cx for each vehicle and requirements definition.	
	56		Radio Frequency ID tags should be considered for stowage items	Consider	Consider design solutions for stowage tracking	
	57		Lunar Surface Ascent Module (LSAM) windows should be designed to see only what is necessary for landing and/or rendezvous with IR protection	Being Evaluated	Requirement in HSIR for non-ionizing radiation exposure, consider for LSAM window spec Level 5 document	HSIR section 3.2.8.3
	58		Design an efficient method for clearing the lunar dust from the vehicle cabin	Being Evaluated	HSIR will have a lunar dust exposure limit.	

ENVIRONMENTAL IMPACTS

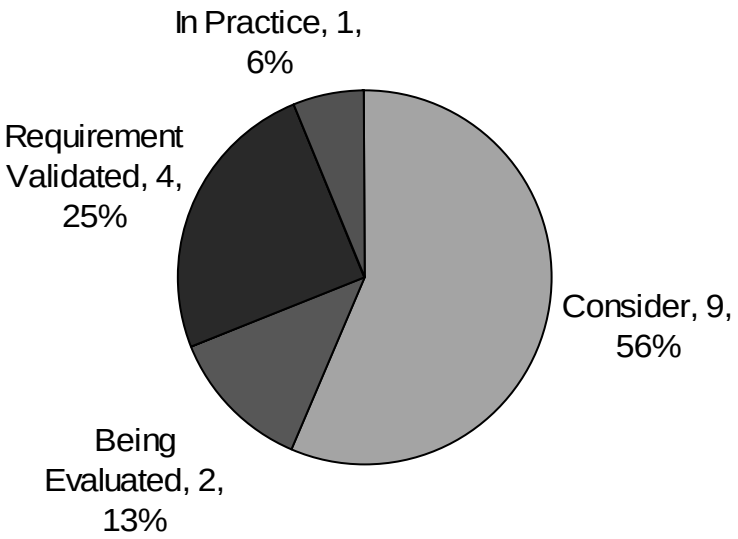

Figure 6. Environmental Impacts

RADIATION

Apollo astronauts were concerned about radiation detection and contingency plans. They stated that all vehicles, habitats, and suits should have radiation detectors and dosimeters built into them. They also recommended that the rover should contain a radiation shield, lunar astronauts should have the ability to create trenches for solar particle events, and that pharmacological radiation protectants should be made available.

Thanks to Skylab, the shuttle, and the ISS, there is a large body of operational knowledge regarding radiation in low Earth orbit; however, radiation on the surface of the moon is not as well defined. The Apollo astronauts were clearly concerned about radiation, and acknowledged that more research needs to be done in this area.

Table 8: Radiation Recommendation Implementation

Cat	#		Apollo Recommendation Summary	Status	Disposition	Reference
Detection	59		The lunar excursion vehicle should have an active radiation detector with an automated audible alarm that sounds when the dose rate exceeds a predetermined level	Requirement Modified	Rover development kicks off in FY2012	
	60		A Personal Radiation Dosimeter is a requirement for all crewmembers and should be designed into suit garments	Consider	Radiation requirement in HSIR; Need also in EVA system and suit requirements document	
Contingency	61		The rover should be equipped with a radiation shield	Consider	Consider for rover requirements document and ARDIG Level 2; being evaluated by LAT2 surface element	
	62		Radiation protectants should be made available to the crewmembers	Being Evaluated	Cx Medical Kit contents definition TBD - research not well funded by NASA at present; some eval by ExMC and EPSP	
	63		Create a trench with shovels or explosives to protect the crew short term in the event of a Solar Particle Event	Consider	Consider for radiation protection Con Ops; alternate strategies being evaluated,	

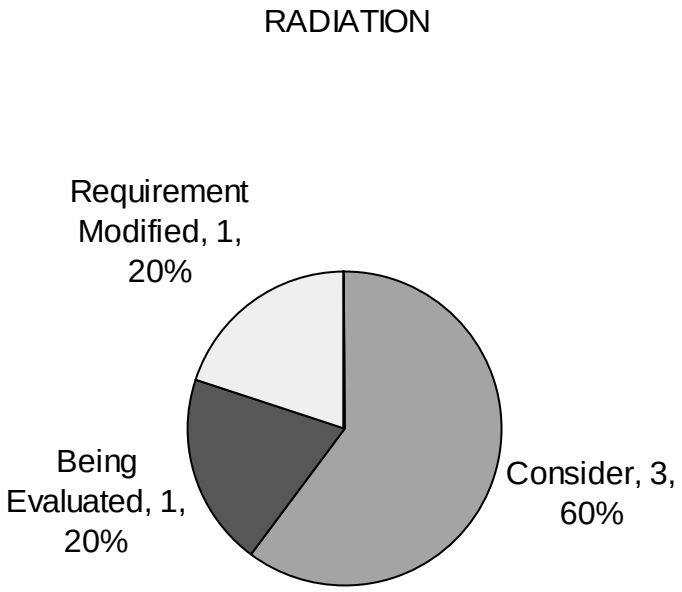

Figure 7. Radiation

PERFORMANCE/HUMAN FACTORS/CREW SCHEDULE

Performance/Human Factors/Crew Schedule generated many recommendations. The recommendations can be broken down into mental (and physical) health concerns and operational concerns. The mental health recommendations dealt with rest and relaxation time, sleep, and psychological preparation. A rest and relaxation consensus statement called for 1 day per week for astronaut discretionary use and the implementation of mental and physical rest plans. Some astronauts also requested recreational activities to be available during down time. Interestingly, the astronauts also displayed empathy and concern for the workload of the mission control teams in the form of a recommendation. Regarding sleep, the astronauts stated that the crew sleep periods should be concurrent, that adequate capability for sleep on the lunar surface should be provided, and that sleep medication use should not be stigmatized. They also unanimously agreed that a minimum of 8 hours of sleep per day must be protected. Regarding psychological preparation and well-being for families, the astronauts unanimously agreed that educational and psychological services must be available to them. The Apollo astronauts also recommended that in the event a crewmember death during the mission, all involved must be prepared to “cut them loose.”

Table 9: Performance/Human Factors Recommendation Implementation

Cat	#		Apollo Recommendation Summary	Status	Disposition	Reference
Mental/Physical Health	64		Recreational activities need to be made available for crews during Trans Lunar Coast and Trans Earth Coast and the CMP during lunar surface operations.	Consider	Private audio and video requirement in HSIR, recreational requirements in development	HS6075, HS6076
	65		Mental and physical rest plans should be introduced into extended moon stays to allow adequate rest between lunar EVA	Consider		
	67		Use of sleeping medication should be encouraged where appropriate	Consider	Cx MORD and Cx Med Kit definition TBD	
	69		Education and psychological services should be available to the crewmember's families	Consider	BHP Requirements in Cx MORD in development	
	71		Provide adequate capabilities for sleeping on the lunar surface	Consider	Details for sleep station in LSAM are TBD.	
	72		If a crewmember dies during the mission you release the body	Being Evaluated	Death management and NASA policy under definition Cx MORD and Ops Con	
	74		Consider the impact on the mission control flight teams and take actions to ensure that they are rested and provided for during the lunar missions	Consider	Consider for GRnC and MCC handbook - TBD	
Operations	66		Mission focus should be project-oriented and not timelined	Consider	Need to capture this philosophy in Ops Con for lunar outpost missions and GRnC TBD	
	68		Countermeasures to combat mental fatigue are necessary throughout the mission	Consider	Medical Operation Requirements are in development.	
	70		Allow adequate time for all activities in the schedule	Consider	Need GRnC entry for this - TBD	
	73		The authority structure is much more significant than crew size when planning crew size/makeup	Consider	Consider development of Crew selection guideline	

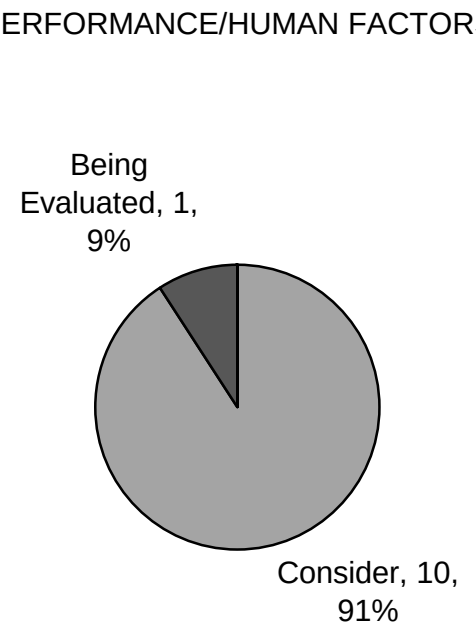

Figure 8. Performance/Human Factors

CREW SCHEDULE

Operational concerns overwhelmingly focused on scheduling issues. Crews stated that the preflight quarantine was very valuable and that the preflight training schedule must allow the crew time to focus on the mission. They also said that throughout the mission including preflight, countermeasures for mental fatigue are necessary and that adequate time for activities must always be provided. They recommended that the mission focus be project-oriented and not time-lined. The final recommendation emphasized the importance of the crew authority structure over all other concerns of crew resource management or crew composition.

Table 10: Crew Schedule Recommendation Implementation

Cat	#		Apollo Recommendation Summary	Status	Disposition	Reference
Operations	75		Preflight quarantine is very valuable because it allows time for simulations, exercise and rest.	Consider	Need to be built into GRnC and crew training plan; Preflight timeline is not in development yet.	
	76		The pre-flight training schedule should allow for crews to concentrate on issues that will be used for the nominal mission	Consider	Consider for crew training plan	
Mental/Physical Health	77		Lunar crews should have one day a week for "rest" (freedom to select their activity)	Consider	Need GRnC entry for this	
	78		An eight hour/day sleep period must be protected in the daily schedule and must not be compromised	Consider	Need GRnC entry for this	
	79		Crew sleep periods should be scheduled at the same time	Consider	Need GRnC entry for this	

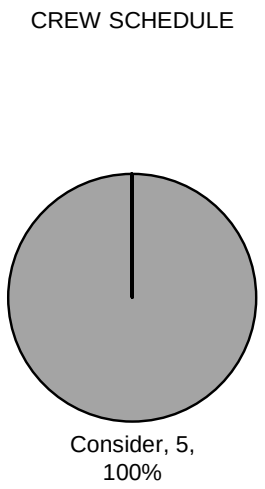

Figure 9. Crew Schedule

EXERCISE

Recommendations regarding exercise centered on scheduling concerns and the exercise equipment. The Apollo astronauts stated that exercise isn't required on trips less than 14 days from a strength/endurance perspective and that exercise prescriptions for short trips were likewise not necessary. Unanimously they stated that the opportunity to exercise must exist for rest and relaxation during all phases of the mission. They said exercise should be required for longer duration lunar missions but research still needs to be done to determine if 1/6 g alone provides any benefit to the musculoskeletal or cardiovascular system. They said that scheduling needs to allocate time for preflight conditioning and that a preflight and in-flight forearm conditioning program be included. The exercise equipment, Exer-Genie, on Apollo missions was considered sub-par, and the astronauts unanimously declared that new exercise devices should be reliable, simple, and safe. They also encouraged that as much exercise variety be built into the vehicle and equipment as possible.

Table 11: Exercise Recommendation Implementation

Cat	#		Apollo Recommendation Summary	Status	Disposition	Reference
Operations-Scheduling	80		Loosen the pre-mission timeline to allow adequate time for pre-flight conditioning program	Consider	Need to be built into GRnC and crew training plan; CxMORD has preflight conditioning as does the Space Flight Health Document	
	82		The flight surgeon/mission planners should not plan specific exercise prescriptions for short duration (< 14 days) mission	Being Evaluated	Not consistent with SA position (we say < 8 days) HSIR requirement for exercise for all missions > 8 days.	HS6032
	83		Exercise is not necessary on short trips (14 days or less) [from a fitness standpoint], however, crews demanded that the capability be available and varied as much as possible for crew "rest and relaxation" in all phases of the mission	Requirement Modified	Not completely consistent with current requirement; HSIR requirement to begin exercise as soon as practical	HS6032
	84		Develop a better pre-flight and in-flight forearm muscle conditioning program for lunar crewmembers	Consider	ASCR pre-flight prep document to be revised from current ISS document for exploration missions. Strength/endurance requirements for mission tasks being developed by ECP	
Engineering-Equipment	81		A more robust (and lightweight) piece of in-flight exercise equipment is needed (The Apollo Exer-Genie was unsatisfactory)	Requirement Validated	Requirement in HSIR; Hardware definition under evaluation by ECP	HS6032
	85		New vehicle design should allow a variety of different exercise capabilities (hardware vs. cabin structure)	Requirement Modified	Requirement in HSIR; need outpost exercise requirements in Level 3 Lunar Outpost Requirements	HS6032
	86		Put as many [exercise] capabilities in the vehicle as possible, because it will get used	Consider	Need outpost exercise guidelines in Level 3 Outpost Requirements; Lunar Habitat Team earmarking exercise area in habitat. H/w under eval by ECP	
	87		New exercise device should be reliable, simple and not develop excessive heat in use	Requirement Modified	Requirement in HSIR; Hardware definition under evaluation by ECP	HS60321

EXERCISE

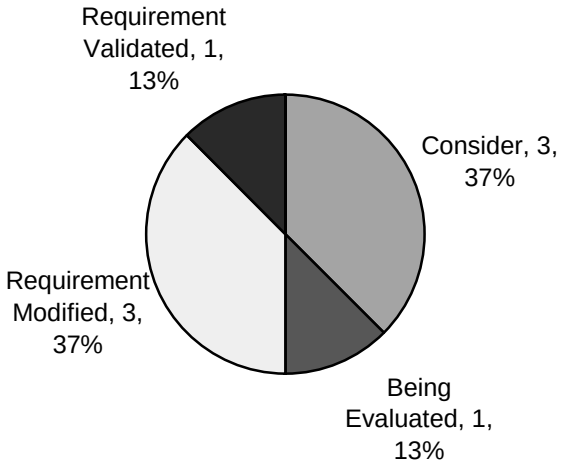

Figure 10. Exercise

FOOD/NUTRITION

The food/nutrition category garnered a number of recommendations. The astronauts commented on nutritional requirements, taste preferences, logistics, and operations. The astronauts unanimously agreed that mission activity dictates the type and amount of food that will be consumed. They also were unanimous in recommending ample water availability for LEVAs and stated that an in-suit source of carbohydrates would be helpful. They recommended that for long duration missions diet and consumption schedule would need to be carefully optimized. Regarding food flavor, the astronauts preferred spicy and salty foods and suggested research into how different environmental factors affect food flavor. There was unanimous agreement that Operations needs to schedule adequate time for meals and the new vehicle should allocate space to store food packs during meals.

Table 12: Food/Nutrition Recommendation Implementation

Cat	#		Apollo Recommendation Summary	Status	Disposition	Reference
Requirements	88		Mission activity (e.g., coast, rendezvous, lunar orbit, lunar ops) will dictate what type and how much food will be consumed. High Activity: wet packages, bite-sized snacks, canned foods Low Activity: spoon bowls, dry juice or meals (rehydratable) requiring mixing, etc.	Being Evaluated	Nutrition requirements will be in Food system specification is in development	
	89		Plain water in large quantities needs to be available for lunar EVA	Requirement Validated	Requirement in HSIR	HS6063

	90		Optimize diet and food intake for overall performance during long duration missions	Being Evaluated	Requirements will be in HSIR	
	91		An in-suit non-caffeinated solid or liquid carbohydrate food source for lunar EVA would be helpful.	Being Evaluated	Under evaluation by EPSP and ExMC	
Engineering	92		Design adequate space an useful area in the new vehicles to store food packs during meals	Consider	Stowage requirement in HSIR, Stowage System specification is in development	HSIR section 3.5.6
Palate	93		Spicy and salty foods were preferred items in the menu	Consider	Food system in development	
	95		Determine how different environmental factors (e.g., O_2 concentration, cabin pressure) effect food flavor	Consider	Need research topic for HRP	
Ops	94		Allow adequate time in the daily schedule for meals	Consider	Need GRnC entry for this	

FOOD/NUTRITION

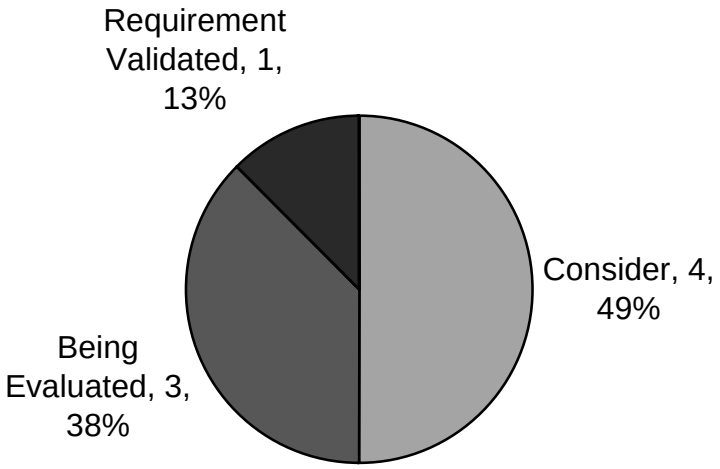

Figure 11. Food/Nutrition

LAUNCH, LANDING, AND RECOVERY OPERATIONS

Launch/Landing/Recovery Operations was broken down into discussions regarding a sea recovery, operations, and engineering ergonomic concerns. Many of the astronauts discouraged ground landings and stated that cooling capability on landing was required to mitigate sea sickness. They also stated that food and water must be within reach of buckled crewmembers in the event of a delayed recovery. Additionally, they stated that the Apollo seats were adequate for water landings and that medications for motion sickness and fatigue should be available prior to re-entry. Operationally, the Apollo astronauts wanted to see a flight rule to limit sea state landings to <6-8 foot swells if recovery is to be delayed. It was also stated that the crew surgeon best fulfills his duty from the recovery vessel not the helicopter. Training for launch pad aborts were thought to be adequate. Regarding engineering ergonomics the astronauts felt that the CM hatch location and size were adequate and that all switches and panels should be reachable during launch and landing. With regards to the landing suits, the crews were in the constant wear garments, not the pressure suits. At some point, the program decided that separation of the SM from the CM was not a true "change of configuration" that posed a significant hazard, hence they did not feel the need to wear the pressurized suits.

Table 13: Launch, Landing, and Recovery Operations Recommendation Implementation

Cat	#		Apollo Recommendation Summary	Status	Disposition	Reference
Sea Recovery	96		Provide adequate cooling capabilities for the crew on landing to mitigate the hot cabin contribution to crewmember sea sickness	Being Evaluated	Cabin environment requirement in HSIR; 36 hr post-landing tiger team working details of ECLSS, suit, etc.	
	97		Ground landings discouraged	Being Evaluated	Land vs. water tiger team weighing trades	
	98		Apollo seat configuration for water landings were adequate: the restraint system needs to include loose equipment items	a. Consider b. Req validated	a. Seat design still TBD b. In HSIR	b. HSIR section 3.5.6
	99		Medication for motion sickness and fatigue will be available prior to re-entry	Consider	Medical Operation Requirements are in development	
Operations	100		Flight rule should limit sea state to < 6-8 foot swells if recovery is to be delayed	Consider	Cx DSNE defines sea state for vehicle; Ground Ops con defines recovery strategy	
	104		Training for pad abort was adequate and should be continued	Consider	Need to include in crew training plan	
	105		Crew surgeon should be on the recovery vessel and not the helicopter	Consider	Details will be in Mission Operation Site Implementation Plans (MOSIPs)	
Engineering	101		Have food and plain water within reach of buckled crewmembers for delayed recovery	Consider	Need to add requirement to HSIR and CEV SRD and 36 hour post-survival Tiger Team	
	102	a)	Apollo Command Module hatch location and size was adequate for egress	Requirement Validated	Hatch requirements in HSIR, vehicle specific hatch dimension in SRD	HS5004
		b)	Hatch should open outward and seal with pressure	Consider	Hatch design is TBD	HS5014
	103		All control panels and switches should be within reach of crewmembers during launch and landing	Requirement Validated	Cockpit requirements in HSIR;	HSIR section 3.6.3.2

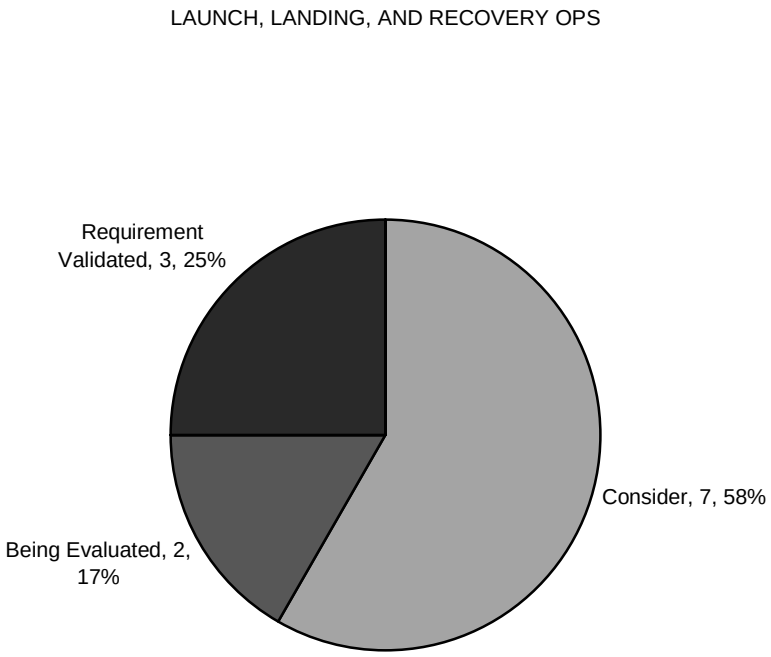

Figure 12. Launch, Landing, and Recovery Operations

FLIGHT SURGEON-CREW INTERACTION

The crews stated that the flight surgeon needs to act as an advocate for the crew and that the collaboration resulting from this interaction between the flight surgeons and the Apollo astronauts should continue and be an example to future generations.

Table 14: Flight Surgeon-Crew Interaction Recommendation Implementation

Cat	#		Apollo Recommendation Summary	Status	Disposition	Reference
Resource Management	106		Crew encouraged FS to "act as more of an advocate of the crew" than treat them as an experiment	In Practice	Currently in practice	
	107		The collaboration established between the current flight surgeons and Apollo crewmembers should continue and be an example to future generations	Consider	Agree and concur	

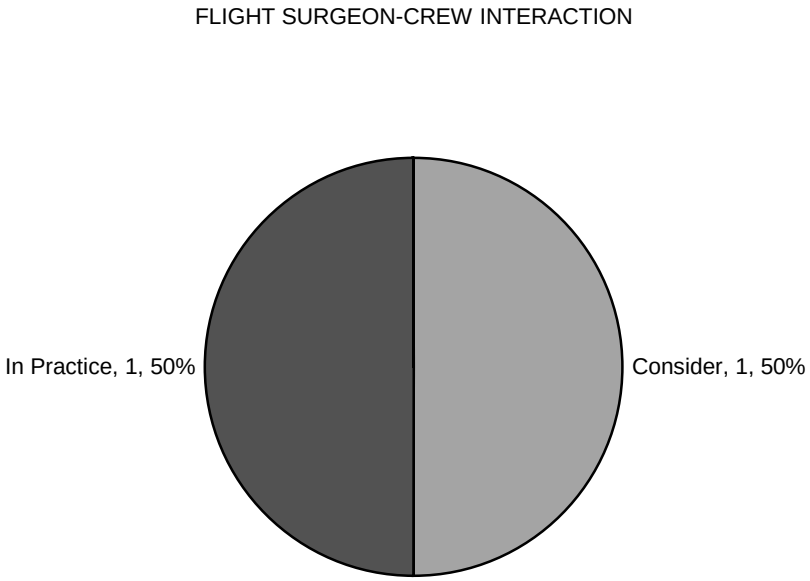

Figure 13. Flight Surgeon-Crew Interaction

SUMMARY DISPOSITION of RECOMMENDATIONS

Overall, the 107 recommendations received were dispositioned into the following categories: consider, being evaluated, new requirements, requirement being modified, requirement validated, rejected, and in practice, The specific distribution of the recommendations is detailed in Table 15.

Table 15. Disposition of Recommendations

Category	Number of Recommendations	Percentage
Consider	54	47%
Being Evaluated	34	30%
New Requirement	2	2%
Requirement Modified	5	4%
Requirement Validated	12	11%
Ops Con Validated	2	2%
Rejected	0	0%
In Practice	4	4%
Totals:	**113**	**100%**

Note that a few recommendations were broken down into multiple recommendations. Therefore, 113 recommendations were dispositioned as opposed to 107. It was determined that cumulatively 23% of the recommendations resulted in a validation or modification, or development of a new requirements or was currently in practice. While 77% of the recommendations are being considered or evaluated. Of this 77%, being considered or evaluated, there is potential for additional requirements to be further modified, validated, or created. Hence, we see that many of the experiences of the Apollo astronauts have been considered relevant, and have impacted the exploration architecture.

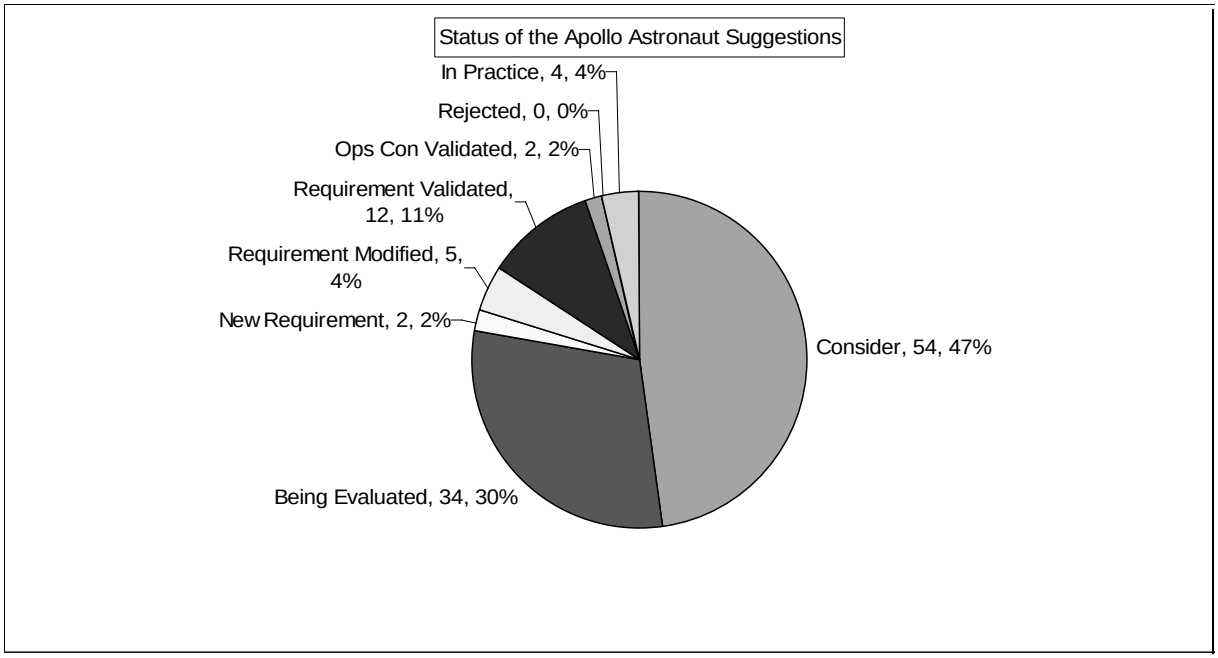

Figure 14. Overall Status of the Apollo Suggestions

6.0 CONCLUSION

The Apollo Medical Operations Project was designed to identify relevant medical operational issues from the Apollo mission issues which had an impact on crew health and/or performance. The goals of this project were to develop or modify medical requirements for new vehicles and habitats, create a centralized database for future access, and to have the capability to share relevant Apollo information with various entities at NASA and abroad participating in the exploration effort. Secondary objectives included using this information to validate current requirements and refresh knowledge regarding lunar operations.

The theme of the Apollo astronauts' 107 recommendations is *res ipsa loquitur* or "the thing speaks for itself." As one of the astronauts said, "Start with what worked on Apollo, and then prove to me why something should be different." The authors likewise feel that the information gleaned from Apollo astronauts' operational experiences is relevant even though the exploration missions have objectives that differ. In other words, the exploration missions are not "Apollo 18." The recommendations contained within this document have broad implications for mission directors, engineers, astronauts, physicians, administrators, and anyone involved in exploration missions. Organizations within the Space Life Sciences Directorate such as the Human Research Program (HRP) have taken action in response to many of the recommendations. Currently, operational solutions to mission relevant problems and issues identified by the Apollo astronauts which affected crewmember health and/or performance are being developed. The HRP has funded specific programs, such as the EVA Physiology and Performance Project (EPSP), Exploration Medical Capabilities (ExMC) and Exercise Countermeasures Program (ECP) to develop hardware or systems based on the results of the Apollo Medical Operations Project. It is important to point out that the EPSP members are currently contributing to the Lunar Architecture Team (LAT) phase 2 study which is addressing issues such as crew habitat concerns, airlocks/suitlocks, suit and habitat radiation protection, EVA navigation and guidance, suit design, and operations.

It is the authors' vision that the recommendations presented here be evaluated by all relevant departments and that the appropriate recommendations become requirements resulting in improved mission operations. Currently, 23% of the recommendations have resulted in development, modification, or validation of requirements or are currently in practice, 77% are being considered or evaluated, and no recommendations have been rejected. It is incumbent on all who read this document to keep the 77% from falling by the waste side.

Future work in this area may includes ongoing dialogue with the Apollo astronauts and additional questionnaire follow-ups to solicit their opinions regarding specific mission operations and implementation of their recommendations. The authors hope that the operationally relevant outcomes of the Apollo Medical Operations Project and other studies like it will contribute significantly to the success of the nation's vision and the Constellation goal of exploring the moon, Mars, and beyond.

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APPENDIX A
NON ATTRIBUTABLE ACCESS DATA RECORDS

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Lunar EVA
Issue:	debrief
Description:	Don't get tired but thirsty. The thirst is due to dry throat in LM suit. Need more fresh water capacity in the suit.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Is the air in the suit humidified enough? Did you have enough to drink in the suit? Was what you had adequate?
Summit Topic:	Yes

Source:	BME logs
Topic:	Lunar EVA
Issue:	EMU
Description:	EMU's also "hot"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How hot was hot? Could you feel them through your gloves? Was this a fire hazard? Was this common?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar EVA
Issue:	Thirst and EVA
Description:	"You don't get tired on EVA but you get thirsty, problem judging distances also"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did you run out or not have enough water in suit? Would something other than water be more beneficial?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Lunar EVA
Issue:	falling
Description:	reports of falling several times during EVA
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How could falling be prevented? Is the suit made to withstand falls? How hard was the perceived fall?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar EVA
Issue:	odor
Description:	"Odor thought to be lunar material"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was this so bad as to affect your mission performance?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar EVA
Issue:	Heart rate
Description:	"1st time gotten my heart rate up while running > 1 hr into EVA while HR >100 the whole time. Hands get tired of holding."
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Why the perceived lack of exertion? Is this concerning physically?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Lunar EVA
issue:	falling
Description:	CDR: Falling over was no big deal. After the first ten minutes had no problem with staying vertical etc. "you adapt real well up there." LMP: after 5 minutes of first EVA, didn't need to 'watch' CG, moving about was natural. You fall so slowly you have time to catch yourself usually. CDR: Could have used a tether to go into a steep crater, maybe 20-25 degree slopes. Soil never had a tendency to slip out from underneath you. Never noticed feet slipping.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Identify risk factors for injuries.
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Lunar EVA
Issue:	Sweating
Description:	LMP: Couldn't work up a sweat during Moon—can't work that hard. On Earth in the centrifuge LMP could work hard enough to require MAX cooling in the suit, but rarely used a short period of intermediate cooling (3 times) on the moon CDR: Used intermediate cooling very little, seated some, but not enough to notice wet feet or anything like that. Inner liners of gloves were always soaked, no good cooling down there.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Lunar EVA

Issue: Heart rates

Description: Both CDR and LMP thought their EVA heart rate peaks were about 20 bpm below what monitored rates showed.
CDR: You will run wherever you move to on the moon. So plan every 1200 feet to stop and rest for about 2 minutes.

Comments: Dr. Berry noted that during the short LM rest periods, the heart rate did not return to a resting rate before activity was resumed. CDR pointed out that during some of the 'rest' periods, they were actually working hard, even though they weren't running. There were always tasks that needed doing to meet the timeline.

Resolved:

If Resolved how, when, where?

Questions: Should lunar activity timeline be project oriented?

Summit Topic: Yes

Source: Medical

Topic: Lunar EVA

Issue: Workload

Description: LMP: Walking around was a low effort, "near the very lowest end of what you do on the bike."
"You can't seem to work too hard up there." Work is limited by the pressure suit. Max effort was either carry out the ASLEP or coming out of the crater.
Those max work levels were "about equal to a little more than half as hard as you go fast on the bike."
CDR: Two times he was tired, one of the times more thirsty than tired, the other was a long run from Sharp crater over to Halo crater." Carrying weight (rocks or equipment) and climbing out of a crater required pacing and a stop of 1 minute and a "shot of that intermediate cooling" was enough to go on. Spent 2 hours in the LM unnecessarily when they could have been continuing the EVA.
CDR: never felt heart rate go above 100--could have gone all day at that work level
Second EVA involved more arm work, working with equipment, always moving. Heart rates higher on 2nd EVA. While running CDR and LMP had HR > 170.
LMP: Felt like 125 or so while running.

Comments: Hands tired after 2nd EVA

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Lunar EVA

Issue: Physical Effect

Description:

a) Effort during LEVA was described as minimal or low-compared to exercise effort on bicycle pre-flight

b) Only increase in physical effort came with climbing out of the crater and long run between Sharp crater and Halo crater
-only required crew to rest for approximately a minute before resuming activity.
-HR averaged 100 bpm, varied with exercise between 120-170 bpm, during the 2nd LEVA
-effort was similar to POGO training activity
-crew felt they could have easily performed EVA for an additional 3-4 hours

c) Sweat was minimal in the suit and was greatly reduced by adjusting vent/cover to max
-hands did sweat in the gloves secondary to lack of cooling
-glove liners were soaked with sweat; apparently learned from Apollo 11 experience

d) crew fell 1-2 times during LEVA, had no problems getting back up

e) shadow pattern made slopes look much steeper than it actually was

f) able to walk down 13 degrees decline to surveyor probe after problem with slope angle resolved

g) surface is not like a desert but more like an ocean with troughs and waves. Not level, more undulating
-navigation was difficult

h) LEVA was limited by fatigue, fluid intake and fluid in part from the suit, not physiological limitation

i) Crews worked during surface rest periods, unbeknownst to the ground. This accounts or the failure of their HRs to decrease while at "rest"

Comments:

Resolved:

If Resolved how, when, where?

Questions: Do the crews feel the pre-flight EVA tripping problem adequately prepared them for LEVA from an exercise capacity standpoint Do crews need a device to better ascertain position of craters in shadows? Does this raise a safety concern?

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Flight Surgeon logs

Topic: Lunar EVA

Issue: Water usage

Description: Crewmember reports 18% less H2O used on CDR and 4% more H2O on LMP

Comments:

Resolved:

If Resolved how, when, where?

Questions: What restricts water usage on EVA? Amount? Ease of use? Taste? Time?

Summit Topic: Yes

Source: Medical Mission Debriefs

Topic: EVA suit

Issue: Environmental cooling

Description: CDR felt strongly that the use of the Liquid Cooling Garment (LCG) by the LMP and CDR while in the LM, while preparing for and upon return from lunar EVA played a major role in reducing insensible and sensible water loss and helped them stay adequately hydrated. This led to a higher performance capability than if they had used LM air circulation for cooling. He compared the feeling of fatigue and dehydration on Earth after using a backpack and air cooling when simulating EVA and the absence of such compromised condition after using the LCG for about 5 hours pre-and post EVA, while in the LM. There is a lot of metabolic work in donning and doffing the EVA suit that is not measured as there is no biomed monitoring during that time. It is important not to get behind with regards to hydration prior to beginning the actual lunar EVA.

Rather than leave the suit ASAP after an EVA, some maintenance and stowage tasks are best done in the suit. It is difficult to don and doff in the confines of the LM. The LCG is very helpful during this time.

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Lunar EVA
Issue:	O2
Description:	Concern using too much O2 to last 7 HRS
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How much extra O2 should we carry than the amount for the EVA?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar EVA
Issue:	Visor scratched
Description:	Visor was scratched during EVA and this posed a problem if looking into sun on EVA
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How did the visor get cracked? Should we carry spare visors for this purpose?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar EVA
Issue:	Snack and water
Description:	Reported taking snack and water on EVA
Comments:	
Resolved:	
if Resolved how, when, where?	
Questions:	How did you do that? Doesn't this mean we need to make sure we have more food and water during EVA?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Lunar EVA

Issue: EVA issues

Description: Removed all the pads from the EVA suit "every little bit of added material you put between you and what you're trying to that your work piece out there - a drill, a rock, a hammer - no matter what it is just removes dexterity from you. You put tape on there, that's another piece of material."

"felt we were very prepared to do the job." Taking a short break and having cold water to drink in the suit for 2-3 minutes and he was ready to go again. "I thought it couldn't have been better." On the first EVA "you got a tougher physical job to do" Learn your capabilities during first EVA and learn adaptation to 1/6 g.

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Source: Medical Mission Debriefs

Topic: Lunar EVA

Issue: EVA issues

Description: Hands very sore and fatigued after each EVA, but cleared overnight each time. Felt fit was good none-the-less.

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Lunar EVA
Issue:	EVA suit issues
Description:	"Perfect glove fit" But after EVA hands were very sore after getting out of suit and gloves. Looked like "a blood blister" on every fingernail-after the first EVA. "They ached to the point that we soaked them in an empty food bag, filled it with water and just let our hands soak in cold water for 15 minutes." By next morning, "we're fine," no problems during 2nd EVA, but ached at end of EVA. At end of 3rd EVA, no problem. Still has yellow marks under some nails during interview "that's just blood" During Gemini, he had hand soreness which took several weeks to clear.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar Dust
Issue:	Lunar dust
Description:	Lunar dust described as fine powder
Comments:	Ubiquitous in suit/cabin. Not easily cleaned.
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Lunar EVA
Issue:	EVA Suit
Description:	Key to success in the EVA suit
Comments:	Know how the human body works and to do as little work as possible we had to constantly fight the suit to perform work.
Resolved:	No
if Resolved how, when, where?	
Questions:	1. Wear a suit that will get you down? (landing) 2. Explain the comment" Know how the human body works and to do as little work as possible" for the use of the EVA suit during lunar EVA?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Lunar EVA
Issue:	glove-suit problem
Description:	When LMP bent his arm the suit elbow pulled his hand from his glove. Unable to correct this problem, but it did not cause a serious problem. His hands were wet, slimy and red at end of the EVA, in contrast to those of the CDR.
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Lunar EVA
Issue:	Duration
Description:	CDR: Could have gone appreciably longer, should the equipment permit it. "Most of the time they were pretty low-level workloads, and those low-level workloads I think you could do for a significant period of time." LMP: "I think you could walk quite a long ways CDR: walking is slow, but hopping lets you cover the ground a good bit faster, but it is a higher workload.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Lunar EVA
Issue:	EVA
Description:	a) Crew could have performed EVA longer if equipment permitted it. Workloads were pretty reasonable, -Crew could wait for long periods -Walking Hopping -more efficient in EMU/EVA suit
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	1. Would fewer but longer EVA be more efficient and save time? 2. Did crews bio reflect reasonable work or not? If not does this need to be addressed? 3. Did crews bio reflect hopping being more efficient than walking
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	EVA suit
Issue:	water and thirst
Description:	CMP: Felt thirsty at times. Juice consumption contributed to thirst. CDR drank most of his in-suit water during 1st EVA LMP drank most of his in-suit water during 1st EVA CDR: "Anything you can do to make it easier is going to help increase the consumption." "Particularly during busy times."
Comments:	Crew had limited H2O carrying capacity in suit.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar EVA
Issue:	Fell
Description:	Fell over rock dropped camera-tired and edgy
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What factors contributed to crew fatigue on the lunar surface?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Lunar EVA
issue:	seat belt
Description:	seat belt got hooked up and caught. They weren't long enough. Took excessively long time to fasten.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Do you think the seat belt was designed inappropriately? Do they need to be longer?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar EVA
Issue:	Fell down
Description:	fell down pulling on rover line
Comments:	Crew stated visual challenges distinguishing features in light and dark areas of the moon. Took the eyes time to adjust.
Resolved:	
If Resolved how, when, where?	
Questions:	How can we better prepare for life at 1/6 gravity? What was the risk for injury?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar EVA
Issue:	Lunar EVA cut short by diminished consumables in suit.
Description:	EVA shortened due to lack of O2
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How much extra O2 do we need? Enough for how long?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Lunar EVA
Issue:	landing radar
Description:	landing radar malfunction
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Lunar EVA
Issue:	sweating like crazy
Description:	"I sweat like crazy" during lunar surface activity. Could not replace H2O adequately with limited suit H2O (15 oz.)
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	This makes plenty of water all the more important?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Lunar Surface Ops
Issue:	Sleeping in the LM
Description:	CDR: lighting, noise and the temperature interfered with sleep in the LM on the lunar surface. Glycol pump was very noisy. CDR and LMP preferred different vehicle temperatures. Got about 2-3 hours of sleep.
Comments:	Crew did not get adequate sleep on lunar surface, presumably because of environmental factors. These can be easily fixed.
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Lunar Surface Ops
Issue:	Sample Boxes
Description:	The surface sample boxes were difficult to close, requiring considerable energy expenditure 1. Biomed data revealed increased respiratory rate and heart rate: however, no numbers were provided
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Should surface sample boxes be interchanged for bags that are then placed in boxes to save time and energy expenditure?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Lunar Surface Ops
Issue:	Fatigue
Description:	Crew reported minor leg fatigue with surface activity (not soreness)
Comments:	Most noticeable with ambulation up and down sloped terrain.
Resolved:	
If Resolved how, when, where?	
Questions:	1. What was exercise schedule like prior to landing on lunar surface? 2. Should Crew work out on treadmill with same "gravity/resistance" as they will feel for their body mass and suit mass on the moon?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Lunar Surface Ops
Issue:	Surface Suit Observations
Description:	The surface suit seemed to work well from an environmental control standpoint 1. No vision fogging on lunar surface 2. Vent / cooling were adequate
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What changes are planned for surface suit? Would any of these adversely affect those things that seemed to work well?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Lunar Surface Ops
Issue:	Locomotion
Description:	"Hopping" on the surface seemed to be the best way to get around with consideration for: 1. Time / distance traveled 2. Energy expenditure
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Can this/should this be practiced prior to arrival?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Lunar Surface Ops
Issue:	Waste Management (non-human)
Description:	Used food packages, etc. need to be disposed of
Comments:	
Resolved:	unknown
If Resolved how, when, where?	
Questions:	Was any garbage taken from the CM to the LM left on the surface? e.g., Urine bags....Crew described that item would be thrown out per "the plan"
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Lunar Surface Ops

Issue: Surface Views

Description: View of the surface from the LM window is different than through the visor on the surface itself
-Looking into the sun toward the horizon was limiting secondary to loss of contrast/resolution
a, Glare, brightness, etc.
-Re-directing gaze down from the sun helpful with surface details
-View in the shadows was good after re-adjustment from the light. However, the light level in the shadow is really low
a. Comparable to the views in the pictures taken by the crew
b. Vision in the crater was acceptable
-Visors were used. both anterior vision in sunlight and inner vision
a. Blinder was used on occasion in the run

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Source: BME logs

Topic: Lunar Surface Ops

Issue: increase HR

Description: CDR thinks he got his HR up during lunar surface activities. Legs not tired but hands are secondary to glove fit issues.

Comments:

Resolved: No

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Lunar Surface
Issue:	Ops bags
Description:	Bags are breaking open
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	Have these bags been corrected or no longer used?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	Misjudging distances
Description:	230 ft LM shadow therefore we misjudged distance, should be 130 ft
Comments:	Crew had depth perception problems secondary to issues with sunlight, terrain features, etc.
Resolved:	
If Resolved how, when, where?	
Questions:	Was this due to miscalculation or due to landing in the wrong area vs. physiological limitation?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	Movement
Description:	Sink in further next to crater nice moving around up here you don't get tired
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	Sample bags
Description:	Sample bags are splitting at the seams
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	Tools
Description:	Tools getting hot to touch
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	If you could feel it through your gloves how hot was it really? What are the expected temp ranges of the tools? Do we know why it got so hot?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Lunar Dust
Issue:	Exposure Observations
Description:	a) Exposure caused nasal congestion, according to CDR and LMP b) Dust floating every where in the LM upon return to 0 gravity. This prompted the CDR/LMP to keep their helmets on c) Dust particles got into their eyes causing irritation d) Dust was ubiquitous, prompting the crew on board to box up item in the LM and send across the hatch to the CMP. They functioned with canister closed until transfer to keep the CM clean.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What did the crew use to treat eye, nasal irritation?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Lunar Surface Ops
Issue:	Fatigue
Description:	LMP: During EVA the right hand fatigued because of the suit valve (the glove and "pipe tangled up" Also unscrewing the core tubes and getting the caps off them was very fatiguing and that arm gave out. Carrying an instrument (lost in dictation) was tiring because it was cumbersome and flopping all around. It was heavy. The flopping of the weights and the longer distance to carry it than in sims made it difficult.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Lunar Surface Ops
issue:	Sleep
Description:	Drank well while on lunar surface, didn't take seconal tonight but recommended to take seconal tonight though they feel they don't need it its still recommended
Comments:	
Resolved:	Yes
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	Lunar dust
Description:	Dirt is soft like powdered snow however it clung to everything- suit, cabin h/w, skin, etc.
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	What did the crew use to clean dust from the suit, environment, etc?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	Lunar RVR
Description:	Handles well stable, lots of roll, need belts that can be fastened easily in a reasonable amount of time.
Comments:	
Resolved:	No
If Resolved - how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	High sun angle
Description:	High sun angle is warm against crew members body during lunar EVA.
Comments:	
Resolved:	
If Resolved- how, when, where?	
Questions:	Did this become uncomfortable during lunar surface ops?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	Dust contamination
Description:	So dirty can't see maps on EVA
Comments:	The lunar dust was ubiquitous during lunar surface activities.
Resolved:	
If Resolved how, when, where?	
Questions:	Were the maps paper? Do they need to be laminate?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	Smell
Description:	Fingers are sore and can smell Lunar dust in LM
Comments:	Glove fit issues are a recurring problem noted in the debriefs and logs.
Resolved:	No
If Resolved how, when, where?	
Questions:	Should gloves be designed differently with the pressure in the suits so fingers are not as sore?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	Eating food
Description:	While eating food it gets stuck in the suit-the food is good otherwise
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	Do you feel food while on a EVA is necessary? Do you think it is worth the trouble/hassle? Does it allow for a more prosperous EVA?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	Walking
Description:	Tricky walking on slopes and soft dirt
Comments:	Sloped terrain was challenging due to limitations in suit flexibility and mobility.
Resolved:	
If Resolved how, when, where?	
Questions:	Explain what tricky means. Could you not judge distance or did you feel like you were going to fall?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	Camera dust
Description:	So much dust on camera can’t get polargraphic filter on
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How can we redesign the lens so that it is not bothered by the lunar dust? What about using compressed air?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	Thirst
Description:	Crew will breakdown before stem? Need some Gatorade could drink 3 gallons.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Would providing Gatorade be better than water in the suits? Do you feel moon EVA is more taxing than space EVA?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Lunar Surface Ops
Issue:	Fatigue
Description:	Never felt excessive fatigue. Any fatigue was relieved with short rest. Not as fatigued as during similar rock pile on Earth. LMP: Never felt tired CMP: "I was less tired when I got back in than I did before I went out." Hardest work was using the drill during an EVA
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Lunar Surface Ops
Issue:	Sore hands
Description:	LMP: after EVA1 fingers were very sore, as was wrist, where the sleeve rubbed.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Lunar Surface Ops
Issue:	Lunar illumination
Description:	Brightness of the lunar surface caused difficulty with vision. Felt sunglasses were OK, but "you can't operate with sunglasses. "Where you want the shielding is in the window. You want to pick up a pair of binoculars you don't look through sunglasses and do that very well."
Comments:	Note: the lunar brightness problems discussed here are when using assisted vision devices, which gather light and focus it, increasing the retinal light intensity -- binoculars and cameras. This suggests the 'fix' is filters, appropriate for the device, at the optical entrance, and filters at the viewing port as needed to protect the crew's eyes (there has been a retinal injury on the ISS secondary to multiple photography of the sunset with a 35 mm through the lens camera. The eye can gather and focus light sufficiently to multiply the retinal light intensity by 300,000 times the incident intensity.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Lunar Surface Ops
Issue:	Visor scratched
Description:	Visor scratched face CMP with face sun during EVA
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How was this problem dealt with?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar Surface Ops
Issue:	tired
Description:	appears tired i.e., forgot bearing and distance during surface activity
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	what will we have to help with not getting lost?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar Dust
Issue:	Lunar dust
Description:	"they are filthy dirty"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What was the best way you found to clean off?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Lunar Surface Ops
Issue:	General
Description:	Slept better in 1/6g, felt refreshed after sleeping, but not as refreshed prior to 3rd EVA. CDR drank all his water during first 2 EVAs and 80% during 3rd EVA. Never ate the entire food bar, but most of the bar during first and second EVA little in the bar during third EVA LMP wasn't hungry or thirsty but used water to moisten his mouth. Both drank a lot during prep for EVA
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Lunar Dust
Issue:	Lunar dust
Description:	"They have become very respectful of lunar dust"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What are the problems we need to focus on fixing with lunar dust?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Lunar Dust
Issue:	Dirt
Description:	Complains of "all of that dirt here again"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Were you able to get rid of the dirt at all or not? Does it pose a problem for the buttons on the ship?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Lunar Dust
Issue:	Stuffy nose from dust
Description:	After first EVA had fullness in head and stuffy feeling. Took couple whiffs of Afrin before bed' with good effect. Wore helmet when stowing lunar samples inside No trouble clearing ears during re-entry
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	Dripping nose
Description:	CDR reports dripping nose; Treated with Actifed and 2 aspirin
Comments:	
Resolved:	Persisted throughout mission
If Resolved how, when, where?	
Questions:	With colds, are symptoms being considered a normal part of space adaptation? How will our approach be different or the same on exploration mission?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	PVC's prior to TLI burn
Description:	2 PVC'S prior to burn within 10 sec of each other with no PVC's during burn
Comments:	
Resolved:	Did not occur again.
If Resolved how, when, where?	
Questions:	Do we know how we will approach PVC's in crew during and before exploration missions?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	Ability to valsalva
Description:	Crews had nasal congestion throughout the mission. They needed to be able to Valsalva on reentry but were unable to with helmets on. Concerned about eardrum hum.
Comments:	
Resolved:	Crew chose not to wear helmets on re-entry.
If Resolved how, when, where?	
Questions:	Will crew be able to Valsalva on reentry while wearing what they are supposed to?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issue:	Health Concerns
Description:	1. "Cold" a) ESD, rhinorrhea, nasal congestion b) Valsalva was useful 2. Little repeat of SMS syndrome
Comments:	b) Definitely need Kleenex on board for rhinorrhea
Resolved:	
If Resolved how, when, where?	
Questions:	1. Are these cold like symptoms different than symptoms experienced with fluid shift? 2. Can we have Kleenex on board?
Summit Topic:	Yes

Source:	Mission Reports
Topic:	Illnesses/Injuries
Issue:	Recommendations
Description:	FR for crew health reporting: 1. State how crewmember feels 2. Medication used 3. Current symptoms 4. Do not take med unless consults with surgeon
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	Lesion and Sore throat
Description:	Lesion of R forearm of LMP microsporia, CDR throat poss for strep
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	Will we have better diagnostic tools during exploration?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	Viral Gastoenteritis
Description:	FS believes Viral gastroenteritis secondary to pre-flight exposure. And sees no cause for radiation exposure
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	On longer exploration style missions will we want more diagnostic capabilities onboard?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issue:	Headache
Description:	Headache post sleep requiring ASA, Seconal
Comments:	Headaches were common among crewmembers. Etiology unknown.
Resolved:	No
If Resolved how, when, where?	
Questions:	Related to carbon dioxide levels?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issus:	Constipation
Description:	More psychological than physiological. The crew did not want to make a mess with the waste management system. One crewmember went entire mission with out BM. Other crewmembers had some kind of problem with defecation post flight.
Comments:	Stools were pasty, not loose. No diarrhea.
Resolved:	
If Resolved how, when, where?	
Questions:	1. Is waste management system improved and more user friendly since Apollo? 2. Can waste management system be used effectively by females? How would this be designed?

Summit Topic: Yes

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issue:	Eye Problems
Description:	Conjunctival irritation treated with unidentified eye drops.
Comments:	
Resolved:	Unknown
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issue:	Space Motion
Description:	a) No vomiting –just nausea, Improvement with limiting movement in the cabin b) Seemed to last 4-24 hours
Comments:	once the stomach awareness and nausea resolved, it did not return Crew with fluids first 24 hours then gradually advanced to solids. Crewmember had decreased appetite throughout the mission Another crewmember vomited X 2 -did not experience this on Gemini
Resolved:	Yes
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	SMS
Description:	SMS that crew attributes partial responsibility to gas in containers
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How will the food and water be packed? Do we still have problems with gas in containers?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	Seborrheic dermatitis
Description:	Face was red like wearing goggles
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did this affect the mission?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Illnesses/Injuries

Issue: Space Motion Sickness

Description: LMP experienced significant SMS during the mission: tumbling sensation, nausea and vomiting, anorexia, his head/neck get out of the suit helmet as in “tumbling my gyros completely”.

Vomiting episode. FD3 was not preceded by any parasympathetic cues, i.e., cold sweats, stomach awareness, vertigo.

2nd episode of vomiting occurred 4-4.5 hours after the first episode in the LM. Traveling through the tunnel contributed to this.
-Symptoms improved steadily after second episode
-Appetite never returned for duration of Mission;

Comments: Marazine slowly helped decrease symptoms for the first two days.
Limiting head movement and moving slowly were keys to preventing dizziness/nausea. However some positions were unavoidable that triggered SMS (i.e., putting heads into suit).

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Source: Medical Mission Debriefs

Topic: Illnesses/Injuries

Issue: Back Pain

Description: a) Back pain for the first couple of days. Described as an "ache" on each side of his lower back.

Comments: Symptoms were relieved by curving back into fetal position, Symptoms more noticeable at night, CM would grab and hold onto his knees in the sleeping bag:

Resolved:

If Resolved how, when, where?

Questions: What position or exercise workout was most effective to relieve back pain?
Do you think there is any pre-flight conditioning program or device to help ameliorate the early in-flight pain

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	Dehydration
Description:	Concern of dehydration b/c of lack of urination felt to be related to gas in water system. Crews had considerable difficulty clearing air bubbles from water bags/system
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What was the daily water intake among Cm's?
Summit Topic:	Yes

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	Apneic periods during sleep
Description:	Sleep pattern with intermittent apnea
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was this noted on earth? Were sleep studies performed on CM's before flight?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	Fiberglass irritation
Description:	Fiberglass irritation of skin causing itching
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Can we keep the cause of the fiberglass from happening again?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issue:	Cause and Affect
Description:	a) Conjunctival irritation secondary to environmental fiberglass. Circumstances not explained. Crew used eye drops, water X2 days without relief b) Skin irritation on landing. No other explanation c) One crewmember with coughing episode. What was source and how did he treat it? d) Biomed sensors caused patchy areas off olliculitis (pustule)
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What was the source of the fiberglass? Is it still being used or will be used?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	PVC
Description:	LMP with few PVC's before TL1 burn
Comments:	
Resolved:	Yes
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	Recovering URI
Description:	Slight injection of Right tympanic membrane and nasal mucosa, Valsalva okay, URI 5 days ago recovering nicely
Comments:	Preflight
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	Seborrheic Dermatitis
Description:	CDR-Seborrheic dermatitis of face and nasal stuffiness took ornade.
Comments:	Preflight
Resolved:	Yes
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issue:	Health Concerns
Description:	a) Lunar dust got in their eyes -Particle cleared on its own – did not require any eye drops b) Took complained of nasal stuffiness throughout the flight. Took Ornade for symptomatic relief c) Crew had no other complaint of illness before, during or after flight d) Crew denied symptom 1. Mild loss of appetite 1st 24-48 hours 2. Minimized head and body movements e) Crew noticed facial puffiness f) Low back pain 1. Bringing knees into fetal position is a position of comfort; Stretching back is no good 2. It was hard to make the feeling in CMP back go away 3. Crew did not complain of back pain upon return to 1 g g) Dust material had distinctive "wet ashes" or gun powder smell to it
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did the crew describe what exercises or positions improved or exacerbated the back pain?
Summit Topic:	Yes

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	stuffy head
Description:	"stuffy head" requiring actifed now and before EVA
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was this secondary illness or space adaptation?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	Middle ear equalization during transition from launch atmosphere of 14.7 psi/21% to en route atmosphere of 5.0 psi/100% O2
Description:	Ears just came down
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	arrythmia during Lunar Surface Activities
Description:	CDR arrhythmia in clump data
Comments:	No further explanation
Resolved:	Yes
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	PVC during Lunar EVA b/w CDR/LMP
Description:	PVC/ dysrhythmia
Comments:	no further comment
Resolved:	Yes
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	T waves larger
Description:	The t waves are excessively tall, increased rate- Is this artifact?
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	ECG changes
Description:	ECG changes frequently from low to high T waves. 141:43 well known phenomenon?
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	laceration
Description:	3/4 jagged laceration to the forehead from camera, which came from unstowed camera at splashdown
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	why was it not stowed away? Was there no room?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	middle ear equalization
Description:	My ears just came down an hour and half into eva
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Is it difficult to equalize middle ear in suit? Was this a common occurrence? Did you normally have problems clearing your ears?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
issue:	lesion
Description:	Weeping lesion like poison ivy on sternal sensor
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was this a secondary infection? What does the crew member account for this?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	stuffy head
Description:	LMP "stuffy head" due to O2 dryness take one actifed no and 1 before EVA
Comments:	
Resolved:	
If Resolved - how, when, where?	
Questions:	How dry was the cabin?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issue:	motion sickness
Description:	CMP: None of the Apollo 12 crew had any motion sickness, not during the flight nor in the Gulf, after splashdown
Comments:	SMS was variable among CM, ranging from non-existent to nausea/vomiting/anorexia.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Illness/Injury
Issue:	Physical Observations
Description:	a) Urination, particularly at night was increased during the first few days of the mission b) Crew made a conscious effort to drink lots of water on this mission, although this dropped off on the way home c) Facial fullness, swelling was not noticeable on FD1, but improved "Just like standing on your head" d) Crew described "coronal discharge" in great detail: flashes in their eyes during the mission, (or streaks of light) -Noticed less CD if they faced toward the moon than away from it -typically occurred in one eye only -Apollo 11 crew described it but it wasn't in the mission debrief
Comments:	
Resolved:	N/A
If Resolved how, when, where?	
Questions:	1. Does coronal discharge pose a problem? 2. What was the average H2O intake per CM per day?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs
Topic: Illnesses/Injures

Issue: Physical Observations

Description:
a) Back pain was noted in all 3 CM. FD0-3
b) Nasal congestion was a problem for all 3CM
-crew related it to possible viral infections, exposure to lunar dust
-surgeon dismissed viral infection and related it to the 100% O2 environment as it was reproducible in ground experiments
-Crew tried to use Afrin (same problem as other crew experience with solution leaking out and decongestants)
Both CDR & LMP -however, this condition resolved on the moon, only to return with entering CM
c) CDR nasal congestion, HA, facial pain persisted through landing. Received tetracycline in the MQR for sinus infection
d) Lunar dust exposure caused conjunctival irritations
e) Biomed sensors resulted in skin irritation and vessicle formation around the electrode.
-the vesicles developed into s. aureus pustule by the end of the mission
f) Crew commented that they experienced no post-landing MS. despite the fact that they had experienced MS with landing -training in the past.

Comments:

Resolved:

If Resolved how, when, where?

Questions: Crew exhibited painful/relieving postures during the interview but did not articulate what there were. It is important for them to describe this as best as possible. Did it involve only the lumbar region or the entire spine?

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issue:	Head stuffiness
Description:	LMP: 3-4 days prior to launch had head stuffiness, worsened during first half day in flight. Blew his nose a lot and used Afrin, which cleared it for 4-8 hours. Didn't think the Afrin spray bottle actually delivered anything in weightlessness. After landing on the moon, his ears did not bother him anymore. But he continued to use Afrin, though he was never symptomatic on the moon. CDR: Stuffy the 1st in flight day, was fine during the first EVA, but back in the LM "I always have sinus trouble anyhow" Felt his nasal stuffiness after the 1st EVA was secondary to "dirt." When pressurizing his suit for second EVA had difficulty clearing his left ear. Subsequently his left sinuses and ears "had mucous" which he attributed to lunar dust. Felt he was getting a cold "the morning that we got up from coming back from the moon." The second day he had other symptoms of a 'cold,' headache, myalgia. CDR: noted he had a lot of dust exposure after returning to the LM, and docked with the CM and transferred gear, etc. "The cabin was so full of junk floating around in Zero G, I took off my helmet and I really blinded myself. I had cinders in my eyes, and that stuff was all over everywhere." I told LMP not to take his helmet off." Positive flow kept all of that stuff out of the command module." CDR: we kept the hatch closed. "I'd just pack one box in the proper bag, I'd open the hatch, and I'd throw it to Dick. He'd give me the LiOH and we'd replace that, and I'd leave the hatch closed." this helped keep the CM clean. Removed suits in the LM and passed them across for stowage in the "L-shaped bag "because they were so damn dirty."
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	stuffy
Description:	sounds stuffy O2 effect suspected
Comments:	Crew members sounds.
Resolved:	
If Resolved how, when, where?	
Questions:	What countermeasures do we have for O2 drying out the crew?
Summit Topic:	No

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	t waves
Description:	transient T waves consistent with ischemia during lunar surface activity
Comments:	
Resolved:	Yes
if Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	rash
Description:	2-3 maculopapular lesions on buttocks
Comments:	
Resolved:	Yes
If Resolved how, when, where?	
Questions:	What did crew attribute this to? How was it treated?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	illnesses/Injuries
Issue:	rash
Description:	2 maculopapular lesions on the L shoulder. Urinalysis WBC/HPF
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	T wave change
Description:	t wave change most likely due to respiration (occurred during rest?)
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issue:	back discomfort
Description:	CDR: Increasing relaxation state while awake helped reduce the back pain CMP: "that small of the back problem was gone after a couple of days, and, in fact, I was kind of surprised at that." All three had back discomfort after the first night's sleep, all agreed it was back discomfort not "zero-g" sensations that interfered with sleep the first night. Dr. Berry suggests the fetal position, CMP agrees.
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	PVC
Description:	PVC on lunar surface during surface activities.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	PVC ‘s
Description:	PVC and short burst of bigimini in CM during lunar surface activities
Comments:	secondary to fatigue says Dr. Johnson
Resolved:	Yes
If Resolved how, when, where?	
Questions:	Will there be specialist consults quickly available during the mission?
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	PVC
Description:	PVC 5 in 1 min and 10 beats of bigemini
Comments:	Dr Johnson feels secondary to fatigue gives seconal to crew
Resolved:	
If Resolved how, when, where?	
Questions:	Should cardiac abnormalities secondary to fatigue give mandatory rest to crew?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
issue:	PVC
Description:	review of strip showed base line shift not PVC
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	PVC
Description:	CMP throwing numerous PVC during TLC.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issue:	foreign body in the eye
Description:	LMP: Two foreign bodies in the eye – from lunar dust when a bag was opened. Cleared "right away" with tears.
Comments:	
Resolved:	Yes
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injury
Issue:	urination
Description:	urinated every 1-1.5 hours in zero g
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Illnesses/Injuries

issue: cardiac arrhythmia

Description: "There's no problem with that, there's no - there's no sign on any of you guys because of anything like that; you can produce that in any individual. You kill laboratory animals with that all the time, as an example. (Laughter)"
"I really think because then we - and then I think we ought to sometime this afternoon if we get that done and off the thing then I think we can write a one-liner right now that says exactly that, that say, okay, we've-all the exams have been done; everybody is back and get off our back,.."

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: No

Source: Medical Mission Debriefs

Topic: Illnesses/Injuries

Issue: Flashes in visual field

Description: Crew saw flashes, as dots or flashes or streaks, CMP also saw them while asleep!?
Detailed description: "like a distant lightning flash in a cloud. It would sort of fill the whole eye. The bright dots were just that -bright while dots, some with halos and some without. The streaks were either pencil thin, clears freaks or fuzzy that went to think and then fuzzed out again." Moving in all different directions and they seemed to be randomly approaching. "The bright dots, you had the impression that they were coming at you..... the flashbulb type, it looked like what I'd call -the bright dots looks like a flashbulb going off. It's like the retinal photography except not quite that bright."
It looked like a cloud particle chamber where you see these things shooting through there. I had the feeling that the things were in the eye (LMP and CDR). CMP did not see them –possibly because of different shielding. Very brief, no after-effect, no color. Dots were very bright, very brief.

Comments: ALFMED -Apollo Light Flash Moving Emulsion Detector --apparently worn by the astronaut. Didn't fit LMP well.

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	S-T segment depression on EKG
Description:	S-T segment depression on EKG during lunar surface activities
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Illnesses/Injuries
Issue:	constipation
Description:	no stool for 3 days, has noticed gas that has caused pain from the pressure, inability to pass normally.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	intestinal gas problem
Description:	3 gas pills yesterday needs more help today any suggestions...crewmember suggests l) eat slow 2) don't chew gum 3) get gas out of H2O ..
Comments:	Crewmember surprised Crew didn't use private line for conversation
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	gas
Description:	gas problems wanted to take Iomotil but FS says not without other symptoms
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	diarrhea
Description:	loose stools or diarrhea by 2 crewmen FS questions: 1) is it an infection-probably not. Too long from start of mission. 2) is it food? Contamination from broken bags of food makeup with high amounts of electrolytes 3) is it in the water? Gas water separation or inadequate chlorination
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	gas
Description:	same problem he had before launch with food: therefore change of diet recommended and take gas pills after each meal and at HS : water gun is not working real well too much gas
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Are the same problems noted in the Shuttle's water system ?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Illnesses/Injuries
Issue:	coughing
Description:	coughing -O2 irritation vs dry cabin air.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How was the air. Was it too dry?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Illnesses/ Injuries
Issue:	cigarette?
Description:	"Yeah, I was lighting a cigarette right after launch, right after dinner, and right before lift off, and I never even felt like that."
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issue:	zero-g adaptation
Description:	Got sick in every T-38 flight: Didn't get sick in zero-g. Just very tired, like he had been up all night. Looking out the window gave false sensation of rolling
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Illnesses/Injuries
Issue:	Headache
Description:	moving around for 15-20 minutes on FD1 caused headache through FD3. FD-4 headache abated, but returned around EVA--felt exactly the same as after 45 minutes of acrobatics in the T-38. very mild. but there. Took ASA X2 CDR had no headache
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debrief
Topic:	Illnesses/Injuries
Issue:	microgravity adaptation
Description:	Did not feel adapted until FD-2 First entry into the LM was an upside down orientation sensation
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	Biomed data drop out
Description:	CDR only CM with biomed data. The LMP/CMP had infrequent data reported to ground. Required waiver on launch.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Are biomed data drops a problem currently with shuttle and ISS? Will this still be an issue with Lunar exploration?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	Continued Biomed problems
Description:	CMP troubleshooting biomed harness reports it’s "not matching up properly"
Comments:	Pneumograph = very poor with increased noise (artifact) No ECG signal "Loose connection pin"
Resolved:	
If Resolved how, when, where?	
Questions:	How have we addressed this trend of poor Biomed feeds and its ease of use?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debrief**s**
Topic:	Bioinstrumentation
Issue:	Design Observations
Description:	a) Spider web-like configuration b) Wires failed -signal conduction & sensor c) Harness/leads were fragile, not up to handling the crew activities/exercise d) Biomed belt had to be removed for defecation (see General Comments) e) Signal condition on OE became warm against his stomach requiring removal. Concerned him because of 100% O2 environment and undergarments were cotton. (See Comments & Questions) f) Band-to-band sound waves on ECG possibly secondary to failing electrical or lead disconnect.
Comments:	Biomed Belt: Difficulty with reconnecting signal conditions and comm adapter: Plug interface did not male well possibly secondary to gas being trapped behind the rubber seal, shoving it off (en route) Crewmember estimated the hardware temp was warm but not hot. Dr. Berry stated approximately 100 degrees Fahrenheit.
Resolved:	
If Resolved how, when, where?	
Questions:	Fire hazard?
Summit Topic:	No

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	Sensor irritating skin
Description:	Upper sternal sensor starting to irritate skin Conduit is hot/warm
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Do current sensors used have same problems with skin irritations Apollo crew noticed? Do we have problems with temperature of sensors?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source: BME logs
Topic: Bioinstrumentation
Issue: "Y" adapter failure
Description: Y adapter failure affected comm replaced with T adapter
300 min of lost Biomed data of CDR in comparison to CMP and LMP
Comments:
Resolved:
If Resolved how, when, where?
Questions: With exploration missions will we have plenty of replacement parts?
Summit Topic: No

Source: Flight Surgeon logs
Topic: Bioinstrumentation
Issue: Biomed Loss of Signal
Description: Biomed disconnect while sleeping
Comments:
Resolved:
If Resolved how, when, where?
Questions: Is the auxiliary power unit disconnected while sleeping? Can we make the biomed work wirelessly with wire back up?
Summit Topic: No

Source: Flight Surgeon logs
Topic: Bioinstrumentation
Issue: poor Biomed data
Description: poor biomed data secondary to poor sternal sensor connection
Comments:
Resolved:
if Resolved how, when, where?
Questions: How have we improved the sensors so they are not a problem on very long term exploration missions?
Summit Topic: No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	no cabin leak rate
Description:	no cabin leak rate data available
Comments:	
Resolved:	
if Resolved how, when, where?	
Questions:	How are we preparing to limit loss of data feeds? What are our "acceptable limits" of lost data?
Summit Topic:	No

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	Biomed probs
Description:	EKG lost, EECOM thinks this whole stateside pass is a “Fiasco” and really had been "Screwed up" in several areas
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How was biomed problems worse on the statsid pass?
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	sleep station hardware not functioning
Description:	hardware not functioning in sleep station so FS unable to identify if crew asleep
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Would we be able to have wireless monitoring so this would not be a problem? We could have back up wire?
Summit Topic:	No.

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	PCO2 sensor malfunction
Description:	PCO2 sensor read 1.0 @ launch therefore FS considers this a bias of 1=0
Comments:	Repeated malfunction of carbon dioxide sensor device
Resolved:	No
If Resolved how, when, where?	
Questions:	Do we need back up PCO2 detector?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Bioinstromentation
Issue:	Faulty biomed sensor and leads
Description:	LMP Biomed leads with bad connector at 2 and broken lead in 3
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Are these problems that are noticed on ISS and Shuttle?
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	sensor discomfort
Description:	The Sensors are drying out. Itching and discomfort under the sensors
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What options of application material do we have for sensors?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	PRD
Description:	CMP stated PRD was all fogged up
Comments:	
Resolved:	
If Resolved-how, when, where?	
Questions:	Will we have back up PRD in case one doesn't work? Explain what caused this?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Bioinstrumentation
Issue:	Electrode Observations
Description:	a) Crew had problems with electrode paste drying cut around FD7-9. Result was itchy and irritations b) Crew felt the mess and set-up with changing the electrodes/apply new paste was more trouble than it was worth
Comments:	Recommend removing the electrodes for one day then re-applying in a staggered fashion.
Resolved:	
If Resolved how, when, where?	
Questions:	Is it desirable to change the electrodes out every day or every other day? Will frequent changing of electrodes cause similar skin problems
Summit Topic:	No

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	Antenna problem
Description:	Antenna problem cause of loss of signal of biomed
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Will we still have antennas on the CEV?
Summit Topic:	

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	Biomed problems
Description:	Problems with Biomed and PCO2 sensor problems
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Bioinstrumentation
Issue:	Sensor Observations
Description:	a) Sensor were irritating, caused backlog. Particularly once the crew took them off approximately FD4 b) Biomed ECG data was good throughout the mission c) Crew does not appreciate daily server changes. Takes too much time
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Are 4 sensors necessary? Can ECG and requests info be obtained with 2 or 3 e.g., Split electrodes (Gemini)?
Summit Topic:	No

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	O2 flow meter
Description:	O2 flow meter pegged full scale high
Comments:	no more mention or explanation of this event
Resolved:	
If Resolved how, when, where?	
Questions:	Was this not considered serious or is this within normal limits? Why no more mention of this?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	Biomed loss
Description:	Lost biomed on CDR and LMP
Comments:	
Resolved:	
if Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	Electrode
Description:	CMP told to renew electrode paste before bed and if it doesn't work will forget about it
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	If we are alright to just forget about it do we even need to have it at all? Is this statement because we are just so fed up with the sensors not working?
Summit Topic:	

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	biomed computer down
Description:	Biomed computer down
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source: BME logs
Topic: Bioinstrumentation
Issue: data drop out
Description: data drop out with biomed sensor
Comments: no more description
Resolved: No
If Resolved how, when, where?
Questions:
Summit Topic: No

Source: BME logs
Topic: Bioinstrumentation
Issue: bad sensor
Description: Bad sensor
Comments:
Resolved:
If Resolved how, when, where?
Questions:
Summit Topic: No

Source: Flight Surgeon logs
Topic: Bioinstrumentation
Issue: bio loss
Description: Com. Lost b/c of failure to change s/c omni antenna
Comments:
Resolved:
If Resolved how, when, where?
Questions: What kind of new technology will eliminate LOS because of antenna placement?
Summit Topic: No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	leads
Description:	LMP need sternal leads to be changed
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	PCO2 sensor
Description:	PCO2 sensor malfunctioning. Notice of change not actual numbers, PCO2 sensor same problem as previous two missions, only goal should be to change sensor.
Comments:	note well that PCO2 malfunction was noted to be solved earlier? Is it or is it not?
Resolved:	
If Resolved how, when, where?	
Questions:	has this problem been solved by calculation changes or is it a mechanical problem? What PCO2 sensor is this the one sent down to ground or the one on the ship?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Flight Surgeon logs

Topic: Bioinstrumentation

Issue: PCO2 sensor explanation

Description: PCO2 anomaly of .8 to 1.5 jump due to calculation curve still set 14.7 psi but cabin at 5:0 psi is this a separate anomaly from the recurrent malfunctions of PCO2

Comments: Recurring problem.

Resolved: No

If Resolved how, when, where?

Questions: Does this explain all the multiple malfunctions? If so why then do we see them still occurring later?

Summit Topic: Yes

Source: Medical Mission Debriefs

Topic: Bioinstrumentation

Issue: Sensors

Description:
a) Sensors dried out requiring all new sensors to be put on. Much less cumbersome than cleaning them off and re-applying
b) Crew felt that bioinstrumentation sensor laboratory was unnecessary in the CM. < 14 day mission
-Reported as uncomfortable, complicated equipment inside pressure suit
-No requirement for

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Bioinstrumentation
issue:	sensor site irritation
Description:	Moved biomed skin sensor because it was irritating his skin
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	loss of signal
Description:	No Biomed? "suit power C/B" may be open
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What are the points where potential problems could arise that would cause a loss of signal?
Summit Topic:	Yes

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	instrumentation sites (sensor application)
Description:	instrumentation sites were breaking out like poison ivy from skin irritation.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was this an allergic reaction?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	biomed loss
Description:	Biomed loss on CDR and LMP for the first night
Comments:	Biomed drop outs continues across missions.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	irritation
Description:	irritation pustules on all sensor sites
Comments:	Sensor pad, conduction paste caused skin irritation among most crewmembers.
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	Loose connection
Description:	loose connection in the CMP's bioharness
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

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Apollo Summit Non-Attributable Report

Source: Flight Surgeon logs
Topic: Bioinstrumentation
Issue: loss of sensor
Description: CDR loss of sensor
Comments:
Resolved:
If Resolved how, when, where?
Questions:
Summit Topic: No

Source: Flight Surgeon logs
Topic: Bioinstrumentation
Issue: PCO2
Description: PCO2 afunctional
Comments:
Resolved:
If Resolved how, when, where?
Questions: Is this the same malfunction that has been noted since Apollo 9?
Summit Topic: Yes

Source: Flight Surgeon logs
Topic: Bioinstrumentation
Issue: PCO2 gauge
Description: suspect that the PCO2 gauge may have failed
Comments:
Resolved:
If Resolved how, when, where?
Questions: How is this problem different than the same thing that happened in previous flights?
Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	Sensor irritation
Description:	CDR irritation at EKG site reattached somewhere else subtly changed wave form. This was reattached incorrectly
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What was done incorrectly to cause this irritation? Was this a flaw in application of the instruments?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	request for no bioinstrumentation
Description:	Crew requests no biomed tonight for better rest
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	"How did biomed affect sleep? How can we change this as to not affect sleep?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Bioinstrumentation
Issue:	Hardware Observations
Description:	a) There was a problem with the biosensor apparently affecting the LMP. Unclear about the details -check FS/BME -apparently the sensor dried out and got hard against the skin b) Crew grew frustrated with the cumbersome taking the electrodes off, cleaning and re-applying. Would rather replace sensors with new hardware. c) Crew developed a rash including clear-fluid vesicles around the sensor site.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did one of the wires develop a short in it causing it to get hot? Crew questioned the need to monitor biomed data throughout the mission. If it is necessary, how do you best do it?
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Bioinstrumentation
Issue:	monitoring time
Description:	CMP: Don't need to be monitored so much. Don't need monitoring while asleep, or during the 3 day coast to the moon. Needless skin irritation and procedures that take a lot of time. Can't zip up in the sleeping bag with bioinstrumentation on..... CDR: the past "boiled up under there." Got blisters. Started itching after only 4 hours, driving me crazy. "Every single one of them looked like poison ivy." Little whelps with fluid in them; like blisters. "Clear fluid in them. CDR had no reaction previously on Gemini flights, even wearing electrodes for 8 days.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What and how long to monitor and what crew activities?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	CO2 reading
Description:	LM CO2 reading 12.5 our CO2 reading 11.4
Comments:	how important is accurate monitors that have been having a problem since Apollo 9
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	PCO2 monitor
Description:	PCO2 monitor 5.9 mmHg although there is some possibility of the sensor failing
Comments:	the PCO2 monitor has been failing since Apollo
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	faulty leads
Description:	replaced faulty leads
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	PRDs
Description:	switch PRDs since one is nonfunctional
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What kind of PRDs will we be using in CEM?
Summit Topic:	No

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	drop intervals
Description:	several drop out intervals
Comments:	no further explanation
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	EKG
Description:	Lost ECG but are a go
Comments:	LMP/CMP had Biomed data dropouts within 5 minutes of launch.
Resolved:	
If Resolved how, when, where?	
Questions:	Crew had data dropouts on Biomed requiring waiver for launch.
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	biomed harness
Description:	will proceed without biomed harness if spare doesn't fix problem
Comments:	How important was it really if they were willing to proceed without it
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	check
Description:	Bioharness check
Comments:	I like to see they are now scheduling bioharness checks but unfortunately its like fixing something that's not broke at this point.
Resolved:	
If Resolved how, when, where?	
Questions:	Did these checks help to keep you on schedule with other tasks?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	leakage of paste
Description:	Leakage of paste at sensor during biocheck
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did these biochecks help prevent problems? I don't see any mention of them in later missions were they stopped? If so, why?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	BIOMED
Description:	biomed lost recommended that he replace his EKG harness with a spare
Comments:	Biomed data lost. Reconnected…
Resolved:	
If Resolved how, when, where?	
Questions:	It doesn't appear that scheduled biomed checks were that beneficial?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	EKG stripped thread
Description:	reports stripped thread on EKG signal conditioner
Comments:	no more information
Resolved:	
If Resolved how, when, where?	
Questions:	Can you shed more light on this event?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Bioinstrumentation
Issue:	Noisy signal on CDR at launch
Description:	Intermittent loss of signal, then noise and low frequency baseline drift, which intermittently reverted to Clean signal CDR: on second day "cleaned it, refilled it, and put a new sticky back on it and put it back on." Also changed the CWG adapter. CDR noted the thread coupling between the sensor line/sensor harness and the best were stripped. It would apparently slip down. The connector at the signal conditioner was routinely disconnected for "bowel movements and for swabbing down and cleaning up process." LMP: pulling clothes off to change or put on the LCG or use the blue bags, all undid the hose. Also removed. cleaned, refitted and replaced one sensor.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	bad sensor
Description:	Exercise period EKG bad or loose sensor
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	resp data
Description:	No respiratory data on all the crew
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	umbilical problem
Description:	umbilical problem no explanation during separation?
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	did the umbilical cord interfere with work?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	PRD
Description:	Switch PRD of the CMP for nonfunctional CDR PRD
Comments:	The PRD has failed multiple times on multiple missions
Resolved:	
If Resolved how, when, where?	
Questions:	Do we need a more reliable PRD?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	umbilical not connected
Description:	discovered umbilical not connected
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	Was remembering to keep the umbilical a hassle? Would not having one be helpful?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	poor ECG
Description:	concern of poor ECG tracing explained to be secondary or lower bit frequency received
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	Was there a problem with all the ECG tracings or just this one time?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	Biosensor sites
Description:	Biosensor sites circled on each crewman-Ducolax taken by all three crewman-All before flight
Comments:	Why ducolax before flight?
Resolved:	
If Resolved how, when, where?	
Questions:	What was the reasoning for circling biomed sites on everybody?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	ZPN
Description:	Bad ZPN-problem debrief gas expansion drives electrolytes out of the sponge causing increase sensitivity to lower cabin pressure than Apollo 9
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Are we still using the sponges? What gas pressure will the CEV be at? Could this problem potentially happen again?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	unplugged
Description:	Unplugged will wait 1-1.5 hrs before request…3 hrs later Request to "get on biomed via the Flight Plan"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did you ever want to keep off your biomed so as not to be hassled?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Bioinstrumentation
Issue:	ZPN (respiration) electrode
Description:	ZPN signal derived via an impedance measurement. The electrode, applied in a 14.7 psia atmosphere failed with depressurization to 5.0 psia. The electrode was removed and expanded gas removed from the sensor pad with manual pressure and the electrode re-applied and it functioned well after that.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Bioinstrumentation
Issue:	don-doff time required
Description:	10-15 minutes. Could save 10 minutes of the time by packaging the sponges to avoid having to cut six open to use five, and making the little sponges somewhat larger than the holes. Berry replies they will take “some lotion to do this?” Entire crew suggested a ‘work station’ for storage after doffing, and to assist next donning of the electrode harness Electrodes caused skin irritation
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	pneumogram
Description:	pneumogram in operation-suspected sensor loss – will not connect
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	chest lead for ECG
Description:	continued problem of sternal chest lead during EVA
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	confusion
Description:	confusion for several hours as to who is on biomed
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	shouldn't this be a decoder as to whose information is being received on biomed?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Bioinstrumentation
Issue:	Sensors and leads
Description:	Suggested a monitoring check before securing for sleep, so they don't get awakened to fix a pre-existing problem, Electrodes were modified after Apollo 15 to reduce skin irritation, but the process of applying and removing electrodes was so time-consuming some crew preferred to just leave them in place between monitoring sessions. Itching was a problem and the itching interfered with sleeping for the CMP. Tape was a problem for some. The allotted timeline of 2 minutes to don and doff biomed sensors usually required about 20 minutes.
Comments:	CMP did not think the monitoring was justified, useful, or a good use of lunar mission time. Dr. Berry states: "I guess the first thing I'd like to say is that I am totally amazed, after 10 trips of manned space flight, at the total lack of understanding that you guys seem to have about why we did some of the things that we did." Followed with a length, detailed explanation of considerations other than 'operational' that influence biomedical activities.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	applying J and J cream
Description:	applying sensors states sensors may not stick well due to application of J and J cream
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Bioinstrumentation
Issue:	skin irritation
Description:	only wearing ECG sensor "giving skin a break”
Comments:	Skin irritation secondary to sensor was a big problem. Crew often chose to give a day without sensor to allow skin to heal.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Crew Questionnaires
Topic:	Bioinstrumentation
Issue:	itching
Description:	itching reported at sensor sites advised of relocation and to take off ZPN sensors
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did giving your skin a break fix the problem or just help?
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	electrolyte sponges
Description:	ran out of electrolyte sponges
Comments:	do we still use these? If we are to use something and it’s important enough to bring in the first place shouldn't we bring extra?
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Bioinstrumentation
Issue:	skin cream
Description:	skin cream cleared up old sensor site
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What was the skin cream?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Bioinstrumentation
Issue:	electrode drying
Description:	biological electrodes dried out after about 12 hours. LMP recommended new electrolyte and procedures as the current system is unsatisfactory from both a skin irritation and a maintenance standpoint. Removal of the electrode revealed a brown scab underneath and no electrolyte paste. Skin electrodes in the CM were different from those in the LM.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Medication/ Medical Kits
Issue:	Use & Amount Dispensed
Description:	a) Actifed for runny nose -threshold secretions (8) b) Aspirin for general principles? (6-8) c) Marezine for nausea -primary (BIG); secondary (prevention) d) Dulcolax taken before flight e) Dexedrine (1 dose) FD7 or so with minimal effect f) Lomotil (2-3 doses) to intentionally delay BM after launch and during flight. However. crew only felt it "quieted the stomach down" by approximately 8 hours g) Darvon (2) h) Nasal emollient?
Comments:	BME log 58:00:xx 6 Actifed consumed, leaving 18 tabs for remaining mission
Resolved:	
If Resolved how, when, where?	
Questions:	How did kit arrangement, allotment of medications impact crew during the mission?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Medication/ Medical Kit
Issue:	Use and Amount Dispensed
Description:	a) 24 tabs Actifed b) 24 tabs antibiotic (urinary class) (See General Comments)
Comments:	Use of antibiotics. Flight Surgeon log – Symptoms treated only when definite evidence of purulence and increased temp, then begin antibiotics Use dexedrine for re-entry as decongestant and anti-lethargic agent
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Medication/ Medical Kit
Issue:	Use & Amount Dispensed
Description:	a) Lomotil (2) for stomach upset b) Seconal100 mg, 150 mg X 1 c) ASA (6) d) Meclizine (Marezine)
Comments:	Seconal left CM with bad headache
Resolved:	
If Resolved how, when, where?	
Questions:	Medication side effects
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Medication/ Medical Kit
Issue:	Observations
Description:	a) 2 kits: difficult keeping track of item in first and second kit b) Eye drops, nasal emollient, hand cream was used c) Need chapstick; however, real chapstick cannot used in a high O2 environment d) Wet wipe for bathing had a putrid odor
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Medications
Issue:	Afrin bottle
Description:	Afrin bottle blows up when trying to open up bottle because not vacuum packed
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How will we pack Afrin in the CEV?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Medications
Issue:	Use and Amount Dispensed
Description:	a) Marazine 1-pre--flight (LMP) 1-in-flight (LMP -1-1.5 in-flight) b) LomotilFD3 (LMP) c) Seconal
Comments:	Confusion with medication durations, interactions
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Medication/ Medical Kit
Issue:	Crew Observations
Description:	a) Nose drops packed at 15 psi basically exploded in medical kit at 5.0 psi, Same for the nose emollient. Big mess b) The blister packs that the MEs were stored in also expanded/cracked. The seconal caps welled like a balloon and pulled apart, sending tiny flakes all over the cabin.
Comments:	b) Recommendations: Pack all MEs in vacuum.
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	BME logs
Topic:	Medications
Issue:	stomach rumbling
Description:	Lomotil taken to calm stomach secondary to H2 ingestion
Comments:	Note the significant trickle down effect of gas in water, Iomotil taken to quiet stomach, which could change normal bowel habits. This also leads to possible dehydration which leads to multiple things including decreased performance, etc.
Resolved:	
If Resolved how, when, where?	
Questions:	Did this cause change in normal bowel habits?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Medical Kit
Issue:	Medical Kit
Description:	There did not appear to be any attempt to evacuate air from the Afrin, other bottles. - Upon opening from the kit, the solution bubbled all over the outside. This rendered the supply kit useless
Comments:	Crew would like to have a fingernail clipper as part of the kit
Resolved:	
If Resolved how, when, where?	
Questions:	Fingernail clippers would be essential in a longer mission and are there plans for this? Are Afrin and other such supplies packed decompressed/in a vacuum so as to alleviate this problem?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Medications
Issue:	Ornade just prior to lift-off
Description:	CDR: "recurring mild symptoms throughout the flight, nasal stuffing, nose would be partially constricted on a couple of morning upon waking up; Did not use any medications for it inflight.
Comments:	Nasal congestion concern for launch, especially with cabin pressure change from 14.7 psi to 5.0 psi
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Medical Kit
Issue:	fingernail clippers and other toiletry items
Description:	CMP: A pair of fingernail clippers would be very useful for hangnails, or ripped fingernails, or removing lunar dust from beneath the nail beds. Also need soap that smells good, rather than musty soap. Deodorant would be useful, and a shaving kit. CDR: soaking a little towel in hot water to wipe off with was very useful
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Medications
Issue:	Benzedrine, aspirin, etc.
Description:	LMP: Took a Benzedrine prior to reentry and again on the water as preventive for sea-sickness after learning of high waves and 6-foot swells at the beach. Took an aspirin each night before going to sleep. CMP: Stated he feels Afrin, Lomofil, Aspirin and Dexedrine should be taken by the crew whenever crew feels they need it, without any radio communications. Stated he feels the CM is secure enough that missions up to 14 days could be flown without any biomedical sensors. "To me the biomedical sensoring is an unnecessary complication." CDR: some individual medications had not been decompressed and Afrin bubbled out
Comments:	
Resolved: If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Medications
Issue:	Usage
Description:	a) Lomotil to prevent BM night (11before landing and night before LM activity (2) b) ASA was taken each night (2) for headaches and to help with sleep c) Crew felt they did not want to report medication usage or their problems because they did not want anyone to know about it (lack of PMC) d) Crew felt that the following medication should be taken by the crew when the crew feels and not required any radio comm with ground Afrin Lomotil ASA Dexedrine
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Has the PMC arrangement with crew and FS ameliorated this concern? Should the use of Iomotil prophalactically so as not to be bothered during landing be a concern? Do we need to develop another plan to assure crew?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Medical Kit
Issue:	Drug Observations
Description:	a) Afrin solution leaked from bottle, similar to previous crew experience -Crew tried absorbing solution onto cotton ball and sniff to deliver medication to nasal mucosa, but this did not work too well b) Actifed used for nasal congestion c) Sleeping pills were taken first couple of days after notifying the ground -LMP would sleep approximately 5 hours, get up take one, sleep another 3-4 hours d) Crew bothered about the lack of confidentiality to take and repeat medication use
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Medications
Issue:	privacy
Description:	LMP: "... one of our big problems; if we take a goddamned aspirin up there, it becomes an international incident. We object strenuously to it." CMP: "Especially this flight crew, just flat-ass object to this type of thing. Now if we can convert, and be able to talk to you like we can right now privately, without the Jim Malone's or the Bill Heinz's (two news reporters) or the rest of the world in on this god damned act, we'd do it. But I'll be god damned if I wasn't damn reluctant to come up and say, I don't know why, maybe this is just a personal thing with me, but I'm sure a lot of the other guys feel the same way." CMP: "Get in the posture where these things aren't flags as a god dammed potential space problem and saying you ought not to be there because you got a headache.., then I think we would feel more free to talk about it." Quotes included to convey the depth of feeling of crew on this point. CDR: Strongly argued for private conversations when the crew requests it. Dr. Berry strongly concurred with the importance of crew being able to talk with ground without unconstrained access to the rest of the world to the conversation.
Comments:	
Resolved:	Yes
If Resolved how, when, where?	
Questions:	Private medical conferences (PMCs) between crew and surgeon are normal operating procedure today.
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Medications
Issue:	Medications for Sleep
Description:	CDR and LMP: would not take medication to improve sleep even if they had been available, CDR noted "You couldn’t sit around in a hammock with the damn neck ring ... In the back of the neck:"
Comments:	Sleep was fitful at best on the lunar surface.
Resolved:	
If Resolved how, when, where?	
Questions:	How could sleep be eventful in the suit?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Medications
Issue:	Afrin bubbles
Description:	There are always a lot of bubbles in the Afrin nasal spray.
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Medical Kit
Issue:	Sunglasses
Description:	Used prescription sun glasses. Used reading correction in low light, Difficult to read small print cards Used them in the LM and a couple of time in the CMS, perhaps a total of 6-8 times,
Comments:	LMP: Cross sun visibility is great. Up-sun visibility is obscured by glare. Down-sun “all the gentle subtle rolling and shadowed craters, they just disappear on you.” Same as with the photographs.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Medications
Issue:	Nose drops
Description:	LMP: 1 drop in each nostril worked for 10-12 hours, for nasal stuffiness. CDR: nose drops helped with the mucous but not the overall fullness sensation CMP thinks he used too much 3 hours prior to reentry, with eye tearing and sensation in his sinuses. Didn't notice any tachycardia with its use.
Comments:	No ear problems at all. Cleared well with pressure changes.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Medications
Issue:	cardiac
Description:	apparently a Seconal was prescribed and the CMP states “except your intent was purely to have some medication to the heart.” To which Dr. Berry answered “Right.” Then the CMP says “That was the idea behind it. And that was the only thing on board which did apply to the heart." To which Dr. Berry answered “That’s right.”
Comments:	Unable to decipher what the real message was.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Medications
Issue:	Potassium
Description:	Concern that potassium powder were contributing to the frequency of bowel movements and loose stools "We're overdoing it" with regards to going to the bathroom enough. "The fact is it was unbelievable, abdominal bloating, 'gas pains" and flatus were also a problem. The odor was "terrible."
Comments:	Bowel movements were sources of difficult hygienic collection and stowage and crew preferred to minimize them.
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Medications
Issue:	Seconal use
Description:	CMD took two seconal, which were the only use of that during the flight. CDR took biomeds, including ASA. General purpose topical skin cream was only other med used.
Comments:	Seconal was very sedative which was a very undesirable side effect.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Medications
Issue:	gas pill
Description:	discussion on how to take gas pills consider chewing them, etc...? Conference on whether or not to talk about Gas problem
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Medications
Issue:	Nausea indication
Description:	label of Dexadrine and Scopolamine says nausea because it used to contain Compazine...used for gas because Gas pill couldn't be found
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Medications
Issue:	gas pills
Description:	took 3 gas pills yesterday
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Medications
Issue:	nausea pill
Description:	medication labeled nausea pills actually medicine for motion sickness
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Medications
Issue:	gas pill
Description:	unknown gas pill reportedly in good container and is mylicon=simethieine 40mg
Comments:	odd that not all the medicines were together and everybody knew what they were
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Medications
Issue:	nausea pill
Description:	nausea pill taken because couldn't find the Gas pill
Comments:	
Resolved:	
If Resolved how, when, whore?	
Questions:	why was this not discussed with FS before this was taken?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Medications
Issue:	itch on arm
Description:	Used skin cream on arm to relieve itch during night, CDR used the cream as an after shave cream
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	Observable Elements
Description:	Brown gunk"-in H2O injector port threads
Comments:	Possible identification of "brown gunk" 1. Molybdenum disulfide (MOS2) 2. Graphite 3. Sodium Silicate 4. H2O 5. Dried Lubricant
Resolved:	
If Resolved how, when, where?	
Questions:	1. Does this present a safety issue?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Cabin Temperature
Description:	Crew felt it was too cold in the CM cabin (cabin temp ranges 67-75 degrees Fahrenheit) and may have contributed to their physical symptoms -stuffy noses, rhinorrhea, etc.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What are the cabin temperatures during rest and activity and can these be adjusted?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Waste Management
Description:	a) Requires approximately 45 minutes from start to end in case there are any problems b) Fecal cannister would be helpful
Comments:	BM Log: For defecation the crew had to strip the underwear off, requiring the biomed sensors to be removed. Resolved.
Resolved:	
If Resolved how, when, where?	
Questions:	Fecal bag recommendation : Calibrations of "crew member anus with respect to the front of the sticky part"?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Water Quality
Description:	a) H2O taste/quality ; b) Ability to measure chlorine level
Comments:	1. tasted poorly prompting repeated chlorination. The chlorination taste lasted10-12 hours; quite unpleasant. Recommend chlorination more than every other day (qod)
Resolved;	
If Resolved how, when, where?	
Questions:	1. Do we have or need water purification SOP's? 2. Do we have the ability to measure chorine levels in water? Can we?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Storage Spaces
Description:	CMP felt the storage spaces for LiOH can was difficult to removed in microgravity under seat / under the couch.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Environmental
Issue:	Difficulty seeing stars
Description:	difficult to see stars from the onboard Navigation system
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Why was it difficult to see the stars and how can we design the CEV to make it easier and better?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Environmental
Issue:	Floating particles
Description:	many particles floating incraft making it difficult to do star counts. Dark adaptation due to lighting also interferes.
Comments:	
Resolved:	
If Resolved - how, when, where?	
Questions:	What were the particles floating? What lighting was interfering with dark adaptation?
Summit Topic:	Yes

Source:	BME logs
Topic:	Environmental
Issue:	Sleep disturbance
Description:	"Pretty fair sleep but every time someone answers comm it tends to wake you up"
Comments:	Sleep was interrupted repeatedly during the mission
Resolved:	No
If Resolved how, when, where?	
Questions:	Will we redesign the comm and sleeping quarters arrangement or will we give something to the crews allow them to not hear the comm while sleeping?
Summit Topic:	Yes

Source:	BME logs
Topic:	Environmental
Issue:	Cabin Temperature
Description:	Cabin temperature 60 degree and CMP reported to be shivering
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What are the temperature regulatory devices on CEV and how tight of temp control will they achieve?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	Decreased cabin temp
Description:	Cabin temp decreased from 77-61 prior to entry.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How can we better stabilize temperature on the CEV in comparison to Apollo?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	Personal Radiation Dosimeters readings
Description:	PRD readings should be done prior to entering Van Allen Belts.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	When are PRD readings scheduled? How will these PRD readings interact with other scheduled events?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	waste dumps
Description:	Waste Dumps causes increase in “pseudo stars” which makes star sightings impossible.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	When should we design our waste dumps so as not to cause a problem with star sighting?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Space Craft Issues
Description:	a) Space craft temperature at launch was 45 degrees Fahrenheit. Crew was in suit but was still c/o cabin being too cold b) Noise level on launch made it very difficult to communicate with crew or round for approximately 42 seconds 1. Noise during setup periods: cabin fans were unacceptably loud. Interfered with sleep period. Cabin itself was quiet except when CMs were talking c) H2O out of gun tasted like chlorine and was disgusting d) Urine collection system was lousy: smells, messy, makes urination an unpleasant experience 1. Collection condom gets sticky 2. Relief tube set up to dump it over the side? 3. Was the most unpleasant part of the mission e) lousy system, created a mess every time it was used f) Pack the bathing towels wet with antibacterial soap g) Dental care was good h) How much H2O is in a "click"? Crew stated they drank "100 clicks per day"
Comments:	Suggestion for Sleep: Use blinders at night for sleep Suggestion for H2O: Mix the H2O with one of the juice drinks Suggestion for fecal dollection: Chemical toilet tore place overboard dump system; Odor in cabin was bad following a BM.
Resolved:	No
If Resolved how, when, where?	
Questions:	How can these issues be improved? (see email correspondence in addition to recommendations)
Summit Topic:	Yes

Source:	BME logs
Topic:	Environmental
Issue:	O2 flow problems
Description:	O2 surge, out of limits Fuel cell O2 flow is high
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Have these O2 problems been addressed?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	window fog
Description:	Hatch window and #1 fog
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Do we need to change how the windows heaters work?
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	comm
Description:	Voice comm wakes up LMP
Comments:	Sleep was interrupted due to numerous environmental, mission related factors.
Resolved:	No.
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	garbage building up
Description:	
Comments:	Garbage building up and moved from CSM to LM
Resolved:	
If Resolved how, when, where?	
Questions:	How can we better control garbage build up on even longer exploration missions?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	LiO2 canister
Description:	CDR forgot to change LiO2 canister
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Is there a better method of removing CO2 out of the air? Does the changing of these canisters seem to be awkward use of time?
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Design Observations
Description:	a) Sleeping Bag did not have enough room for crew to assume "fetal position" b) Traveling through the tunnel to the Lunar Module was disorienting because everything is reversed from the Command Module
Comments:	It sounds like the crew was very uncomfortable secondary to back pain when strapped down in the couch,
Resolved:	
If Resolved how, when, where?	
Questions:	How were in-flight position, for comfort accomplished in the couch? It appeared that the LMP had to put on the suit each mission. Why?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Personal Hygiene/ Environmental
Issue:	Defecation Issues
Description:	Crew preferred to strip naked to move bowels.
Comments:	Same complaint in earlier Apollo missions
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Design Observations
Description:	a) Sleeping Bag did not have enough room for crew to assume "fetal position" b) Traveling through the tunnel to the Lunar Module was disorienting because everything is reversed from the Command Module
Comments:	It sounds like the crew was very uncomfortable secondary to back pain when strapped down in the couch,
Resolved:	
If Resolved how, when, where?	
Questions:	How were in-flight position, for comfort accomplished in the couch? It appeared that the LMP had to put on the suit each mission. Why?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Water Quality
Description:	H2O was bad, heavily chlorinated, sensation in CM mouth. CM had to throw bag away and resort to water gun.
Comments:	Water gun had a let of store H2O in drink bag,
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Environmental
Issue:	Frequent thruster firings
Description:	"Complains of frequent thruster firing"
Comments:	This kept CM from Sleeping/getting deep restful sleep
Resolved:	
If Resolved how, when, where?	
Questions:	What was the cause of these thruster firings? How can we change the sleeping environment in order to assure a deep restful sleep without unwanted disturbances? How will we assure being able to wake CM if needed
Summit Topic:	Yes

Source:	BME logs
Topic:	Environmental
Issue:	Insulation material broke off
Description:	Insulation material near pressurization valve in forward hatch area. Material fractured and snowed in LM all over CSM has caused scratchy and itching for 3 days
Comments:	Is this material fiberglass
Resolved:	Yes
If Resolved how, when, where?	
Questions:	Will the CEV have fiberglass in this area? Could a different, stronger material be used? Is this a freak incident, or does it need to be addressed as a redesign?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Environmental
Issue:	primary evaporator
Description:	Primary evaporator turned “Off" How did this effect environment? "Usual chilly self"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How does the cold environment affect work?
Summit Topic:	Yes

Source:	BME logs
Topic:	Environmental
Issue:	condensation on tunnel hatch needs wiping down occasionally
Description:	
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How much condensation will be found throughout cabin? Does this pose a problem? Do we need to prepare a CEV for wet conditions? Did this interfere with the mission at all?
Summit Topic:	Yes

Source:	BME logs
Topic:	Environmental
Issue:	waste storage
Description:	Can’t stow waste in L1 L3 since still all full of food. Food waste left in storage box on LEM
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How should we or should we approach waste/garbage storage especially in light of longer exploration missions? How often was this a problem?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	Chlorination of water
Description:	Confusion on rather to open inlet or not during chlorination. Therefore got a slug of Very chlorinated water
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Rather we use chlorine or iodine we should have it brutally simple on how and when to use?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	trash storage
Description:	Concerns of trash storage problems
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	how do we currently take care of trash, how is this different than what was used with
Questions:	Apollo?
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	coughing from fiberglass snow in CM
Description:	coughing from fiberglass snow in CM
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Could this happen again? Dose this pose a current problem?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	Thruster awakens CMP
Description:	CMP awakens each time thruster fires
Comments:	Sleep was sporadic and frequently interrupted
Resolved:	
If Resolved how, when, where?	
Questions:	Will our countermeasures for Comm interrupting sleep also help with Thruster interruptions?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	fiberglass snowstorm
Description:	"Snow storm of insulation material is in LM "Snow in CSM also" Like Fiberglass
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Where did this fiberglass come from? How did this happen?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Space Craft Issues
Description:	a) Water chlorination process is to be done within 12 hours of launch, if the crew launches on time. The chlorine valve is left closed from launch. Chlorine applied to the systems lasts 12 hours; however, the crew had not used the system, which extended > 12 hours. b) Bubbles found in the water bag likely because O2 gas diffused across the bladder. The problem was fixed by de-aerating the water before launch in the bladder. c) Rested good according to crew. d) Crew started out drinking approximately 3 lbs of water per day. Gradually this was increased to normal range of 7-7.5 lbs per day. e) Hot water had more gas in it than the cold water. f) Waste management reported that it was a "mess"
Comments:	a) Make sure you chlorinate with the valve open, otherwise, very light level of chlorine in water. Need to pay particular attention to this in the event of delayed launch. b) Crew was upset by the presence of gas in the water system because it was passed into the stomach creating fullness and flatulence. Preventing eating. c) Urine output was twice a day secondary to low oral water intake according to crew. However, volume was considerable filling urine tank with each void. d) Urine collection was dumped overboard. Crew reported they opened the dump valve before voiding. The suction created was not strong enough e) The urine bag, if used, caused back pressure. f) CDR suggested designing a diaphragm at an angle to prevent back splash. g) Crew was very concerned about voiding ability during time-critical OPS the amount of time it took to get set-up for a voiding dump.
Resolved:	Yes- gas bubbles in water system
if Resolved how, when, where?	
Questions:	a) Is it necessary to chlorinate the system if it hasn't been used yet? b) What about fuel cell water? Was this a problem? c) What is Ammonia, germicide, fungicide, detergent and deodorant used in?
Summit Topic:	Yes

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Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Environmental
Issue:	cabin temp
Description:	CDR shivers periodically with coinciding increase in HR cabin temp 65
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Does the temp accurately estimate how it feels or does it change with the different conditions?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	pressurization
Description:	cabin pressure 4.5 during pressurization it was 5.6
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Does this represent a leak rate that is out of normal range since it was mentioned?
Summit Topic:	No

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Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
issue:	O2 flow rate
Description:	O2 flow rate transducer is suspected of having failed. Plan to close waste management valve tonight in order to recruit PTC without thruster activity for better crew sleep.
Comments:	This statement is confusing it seems as though they are talking about 2 different things.
Resolved:	
If Resolved how, when, where?	
Questions:	Is the O2 transducer or sensor a problem similar to the PCO2 sensor?
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	Cabin temp
Description:	cabin a little on the warm side no moisture
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	was the cabin hot or cold, or did it fluctuate a lot, and how did this affect you? Was the cabin moist or dry or did this fluctuate?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Personal Hygiene/ Environment
Issue:	Urine collection system
Description:	p.25: LMP: The urine and feces collection systems are lousy. The odors inside the cockpit are quite bothersome. No good way to wash after a BM. Need some atmosphere control. "I think the gases in the hydrogen and the water just circulate through your system so you end up passing a tremendous amount of volume of gas in there." Fixing these areas would "make it a lot more livable." CDR: We have vacuum outside that could be used with a well-designed urinal.
Comments:	In general, the WCS was broken.
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Waste Management
Description:	a) BM's were reported by crew -approximately 2 per CM during the mission b) Crews performed house cleaning in two ways: 1. Took hose blowing air out and directed dust toward the accumulation system 2. Cleaned filter screen c) CDR got thirsty during mission –drank a lot of water. Tried to avoid beverages as they were too sweet d) No problems with urination (from physiological standpoint) e) Urine and feces collection system is lousy. Crew would prefer no bag at all f) Odors in cabin were awful -SOLUTION: Circulate cabin gasses g) Shaving was cumbersome. Could not get your face wet enough h) Improved wet wipes, preferred soap
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Crew describes something floating in cabin during conversation of BM frequency. What were they talking about? Dust vs.?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Personal Hygiene/ Environment
Issue:	Crew Preferences
Description:	a) Deodorant in hygiene kit b) Preferred wet wipes (recommendation since Gemini, Apollo 7) c) Vacuum bottle for arm grab sample to locate source of the odors
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Environmental
Issue:	solar flare
Description:	small will miss altogether
Comments:	The radiation contingency plan was based on a number of assumptions. Also, reduction monitoring was not real-time
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Environmental
Issue:	window fogging
Description:	window too fogged to send TV pictures
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Were the window heaters working? Did you have window heaters? How common of a problem was this?
Summit Topic:	Yes

Source:	BME logs
Topic:	Environmental
Issue:	lunar dust clean up
Description:	cabin mode to clean up dirt
Comments;	
Resolved:	No
If Resolved how, when, where?	
Questions:	What kind of system and how effective were they at cleaning up dust? Were the particles static propelled if so would sanitized cleaning help?
Summit Topic:	Yes

Source:	BME logs
Topic:	Personal Hygiene/ Environment
Issue:	urine dump
Description:	Leaving urine dump open most of the time because it doesn't flush well
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was this because the filter was clogged? Did this cause adverse effects during the mission like an increase in leak rate?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	solar flare
Description:	25% chance of solar flare
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Will shielding on the CEV Be better in light of exploration style missions?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	Solar flare
Description:	Solar flare possibility of 40%
Comments:	Radiation detection capability
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	solar flare
Description:	small solar flare no increase in radiation
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

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Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	ASA heater
Description:	ASA heater may not be cycling
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was it cycling or not? What caused you to think it wasn't?
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	sunburst
Description:	sunburst radiation to be determined
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	lightning strike
Description:	Things back to normal" "20430 Alarm" integration problem – Pete thinks they got hit by lightning on launch.
Comments	
Resolved:	
If Resolved how, when, where?	
Questions:	What was the effect of the lightning strike? Electrical loss?
Summit Topic:	No

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Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	urine dump
Description:	failing of 2nd urine filter. 1st urine filter failed 4 days ago, Ask if they can dump without filter. No it would clog use another system
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How many spare urine filters will we need? Was this a common problem?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	decongestants
Description:	crew taking decongestants because of excessive dust
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What countermeasures were on board for this condition if any? If so how effective were they and how can they be improved?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	LIOH canister
Description:	switch to primary LiOH canister with no increase in PCO2
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Is this caused by a faulty PCO2 monitor?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	urine dump
Description:	urine dump-takes a long time for it to dissipate-it just hangs on
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What problems did this cause?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	window
Description:	white deposit build up on the outside of the windows
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What was this, was it ice? Did it obstruct vision?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	LiOH canister
Description:	on back side of moon PCO2 went up to 7.0 mmHg they switched to secondary canister and a drop to 0mmHg
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was this caused by a failed canister? If so do we carry spare?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Radiation
Description:	The crew received 200 mrads upon return to the Earth
Comments:	
Resolved:	
If Resolved how. when, where?	
Questions:	What did the crew receive upon return to Earth that gave them 200 mrads? Was this an X-ray? Was this totally necessary or could this have been adequately evaluated using some other modality?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Waste Management
Description:	a) Crew highly recommends creating a device that would allow them to assume a squatting position to have a BM -"Make the guy's BM like as close to the way he is used to living, and provide the least possible facilities" b) Crew preferred urinating into the device used for this mission over previous mission, where they urinated in a bag after placing a condom on the penis.
Comments:	This complaint extended across the mission.
Resolved:	No
If Resolved how, when, where?	
Questions:	Please provide specific examples of breakdowns in H/W and suggest areas for improvement.
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Part II
Description:	Noise was loud, but tolerable (adaptable)
Comments:	Crew complained of noise level in LM, stating it interfered with sleep, concentration.
Resolved:	
If Resolved how, when, where?	
Questions:	How noisy was it on the LM? -CMP could hear background noise -Repressing the LM cabin was louder
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Part I
Description:	a) Water system seemed to be functioning well especially the cold water. Crew did not complain of any bubbles in the system b) Lunar dust did not appear to be filtered from the environment from the LiOH canister c) Mobility was important issue, especially to the Gemini veterans
Comments:	
Resolved:	Yes, apparently.
If Resolved how, when, where?	
Questions:	What changes occurred in the water system between Apollo 7-11 and 12 to improve this problem with bubble/gas formation?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	LiOH canister changes
Description:	Crew forgot to make the LiOH change just after leaving lunar orbit. About 12 hours later, the change was made. No consequence to the late change.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Personal Hygiene/ Environment
Issue:	bathroom facilities
Description:	CMP: ".. I think the key to this thing is if you can make the guy's life as close to the way he's used to living, and provide the facilities, the easier it's going to be for him." "the fact that we had something that we could put a stream of water into, just like we do here, made that whole operation seem a hell of a lot better."
Comments:	Highlights the issues associated with Apollo WCS.
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Personal Hygiene/ Environment
Issue:	wet wipes and fecal bags
Description:	Wet wipes and fecal bags don't have any velcro on stem and subsequently leak. Crew found using this system very difficult and messy.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What will be using during exploration? How would velcro help fecal bags and wet wipes?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Personal Hygiene/ Environment
Issue:	Bowel movements
Description:	LMP: one BM before LM activation, one after the return CMP: one BM the day before LOI and one the day after TEI. CDR: one and an eighth.(?)
Comments:	Crew noted difficulty with using WCS, specifically in ability to assume squatting position, no odor control, etc.
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Lunar Module
Description:	LMP: ".. It looks to me like big problem is the dirt, you've got to keep the dirt from bothering your suit. If you can do that, you're going to have a good time up there at the moon." The noise required a night or so to accommodate to, then was OK, "like taking the country boy out into the city. Couldn't sleep when he hears the trains, and the cars the first night but he does get used to it."
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Flashing lights
Description:	CDR: "We closed our eyes and faced the moon, when we were orbiting it because it would be more-you get less discharges facing the moon than away from it." "Get either a streak (strikes the eyeball parallel) or a flash (strikes the eyeball perpendicular)" LMP: I saw them in either eye or in both eyes.
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Salutory effect of vehicle volume
Description:	CDR: “The thing that was different between Gemini and Apollo that I noticed right off the bat, nobody ever stopped moving when we were awake." "I think that's one of the reasons, the fact that you're free, and everything, I felt a whole lot better than I did on any of those Gemini rides. I mean, I could tell I was going down hill a log on those things, on every day that went by, it didn't matter whether it was a short one or a long one. But I never felt that way on this, I really felt good. But we all moved, and somebody was -you were always moving something." CMP:" I felt better in 10 days in this one that I did in 3 days in Gemini, by far, a hell of a lot better."
Comments:	The increased vehicle volume of the Apollo TEl configuration had a definite salutory effect on crew, compared to the confined volume of the Gemini vehicle.
Resolved:	
If Resolved how, when, where?	
Questions:	What inferences can be made regarding even longer-duration missions?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	Radiation
Description:	Goofed and left PRN on stowed PGA's
Comments:	Radiation monitors were frequently “left behind” by CM on lunar surface.
Resolved:	
If Resolved how, when, where?	
Questions:	How can you incorporate this device in the suit?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	temp
Description:	35-40 degrees in CM too cold to sleep in there
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	What could be done to prevent crews from suffering hypothermia in the event of a power failure?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	PCO2
Description:	PCO2 increase rates is .15 mmHg/hr curve is not linear but exponential
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	LM O2 usage
Description:	LMO2 usage rate <.25 LBS/hr
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Environmental
Issue:	CSM cabin pressure
Description:	A lot of discussion on fall in CSM cabin pressure over past hour to 4.5 psi. terminating O2 flow test
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What was the cause of this?
Summit Topic:	Yes

Source:	BME logs
Topic:	Environmental
Issue:	high O2 flow
Description:	high O2 flow - urine dump not completely closed
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How can we make the urine dump to always close?
Summit Topic:	Yes

Source:	BME logs
Topic:	Environmental
Issue:	temps
Description:	temp values suits 47-48 more real than cabin, which is 60-63 but in static atmosphere none really applicable to comfort
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What temp values should we go by to determine temperature and comfortability?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Environmental
Issue:	probe removal
Description:	"have pretty fine snowstorm" must have opened the hatch for removal of the probe
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Can we have more explanation as to what this event entailed?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	light flashes in eyes.
Description:	3 types are described: 1) stars 2) supernova 3) streaks
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Characterize the light streaks/flashes with regards to crew activity.
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	High O2 flow alarm
Description:	High O2 Flow alarm
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Do we know what caused this?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	O2 flow
Description:	O2 Flow rate high
Comments:	cause undetermined
Resolved:	
If Resolved how, when, where?	
Questions:	Was this caused from the urine dump not closing like it had been from other flights?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Personal Hygiene
Issue:	Bowel movements
Description:	Had first BM on 8th mission day! Wore a bag for about 12 hours prior to EVA without result. CDR had BM on 3rd and 7th days. All agreed defecation and collection were "gross, and markedly unsatisfactory from a hygiene and civilized aspect. CMP had first BM at 80 hours into flight. Next was the day after TEI
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What specifically could be done to improve the WCS?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	In-suit urine collection
Description:	Urine drain line kinked “apparently” all the time.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Visual flashes
Description:	LMP: very sharp flashes, straight,.., instantaneously,.. CDR: "The single streak and the double shot appeared to be very clear to me." CMP: "quite clear...most of my streaks appeared to be on the periphery... CDR: ...side, from left to right. "generally random" LMP: couldn't really correlate a pattern out of it. LMP: a couple looked like lightning in a cloud
Comments:	Some flashes were streaks, some were pinpoint, some were larger 'blobs' During a test period, some eyes were open, some closed. LMP described 18, CDR had 14 and CMP had 8 visual flashes On three occasions two persons reported a flash simultaneously After very bright ("nova or super nova") flashes a 'halo' effect was described Crew described the flashes as 'definitely' in their eyeball, not in the cabin. CDR: no preferred orientation of flash
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Environmental
Issue:	LM
Description:	venting LM to get to 95% or better O2
Comments:	comments in FS logs states they think crew misread gauges
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	broken glass
Description:	glass cover of TV tape broken but able to be suctioned
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	O2 enrichment
Description:	2nd LM enrichment procedure -O2 suit environment 95% at SEVA 91-92% increase LM psi by 4 psi to 5.45 psi
Comments:	
Resolved:	
it Resolved how, when, where?	
Questions:	Why did it take 2 pressurizations/enrichment procedures to get this? How many do we expect to achieve this?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	low O2
Description:	info from SPAN-Cabin O2 88%-Estimated O2 at end of SEVA 91-92%-continue O2 enrichment procedure
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What caused the low O2%?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	water leakage
Description:	water leakage around panel 352 around H2O chlorination problem seen in previous tests so fixed with special tool
Comments:	
Resolved:	
if Resolved how, when, where?	
Questions:	Why can this problem not be addressed and fixed so as not to need a special tool? What exactly was the cause of the problem
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	leak rate
Description:	leak rate so high in LM -may bleed pressure in O2 tanks so low that it will eliminate EVA-3
Comments:	urine valve was open -quick disconnect not capped
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	Radiation monitors
Description:	There were three different types of radiation monitors: 1) kept in EVA suit pockets 2) super D on the wall, a large instrument 3) three small packages in their garment
Comments:	"certainly not coordinated" " you ought to settle down to one system and prescribe some positioning of the suit so that we can keep hold of them." *When we took the suits off, we stuck them down in the suits and then we'd get all them out and they'd been buried there all that time."
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Personal Hygiene/Environmental

Issue: bowel movements

Description: "about every other day" but not tracked.
One person missed three days, but averaged every other day.

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: No

Source: BME logs

Topic: Environmental

Issue: water dumped

Description: 1 and ½ lbs of H2O dumped in CM prelaunch, question whether to replace chlorination, replace buffer only

Comments:

Resolved:

If Resolved how, when, where?

Questions: Did water spill out of the tanks into the CM or LM often?

Summit Topic: Yes

Source: Flight Surgeon logs

Topic: Environmental

Issue: solar flare

Description: solar fare reported 4hrs/ago no increase in arc radiation

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	LM
Description:	particles coming off LM in area of tank-entered LM -looks good
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What were the particles that were coming off the tank? Was this inside or outside the cabin?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	chlorine ampule
Description:	1 chlorination ampule broken, leak in adaptor 2 small holes
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How fragile were the Chlorination ampules? Did these pose a safety hazard?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Personal Hygiene/ Environmental
Issue:	sweating
Description:	"You sweat a lot on the surface. Sweat at hands, bottom of feet, and groin, A lot of waste water on the PLSS.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did the suit accommodate the increased suit condensation?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	urine collection
Description:	The collection of urine samples was seriously impaired by the urine collection system which resulted in urine soiling of individuals, spilling in the vehicle and difficulty with the check valve. "CM didn't work at all." "The data is meaningless." "Does a guy want to pee all over himself or does he want to log your satisfactory flow rates? You're going to get one or the other. You are not going to get both, not with that kind of system." Dr Berry: "What do you mean by that, CM? They get "stickier and stickier" as the mission progresses.
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	water bags
Description:	There were air bubbles in the water which also changed the water taste.Crew estimated 20-30% of bag volume was air. Far more gas in hot water than cold water Juice bags were not filled every time, estimated water gun strokes were used to add water to juice bags. Water gun was not consistent, difficult. Filling the bag up before you can drink was operationally involvement and particularly not useful at night. Had to drink the entire bag once you started -no wetting your mouth or partial drinks per thirst level
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	urine collection
Description:	New procedures which crew felt were incorrect, could not be discussed because there was no private communication and “you can’t discuss these things in a rational manner. You have to do them. Although that was a dumb procedure.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	new fecal bags
Description:	"We'd like to go back to the old ones and take the finger out." Not clear what that means. Fecal bags were returned to earth. They were not gas-tight and were completely filled. Concerned about bags bursting during EVA. Not compatible with an operational mission. Is there any justification for it? Consider the health hazard if a bag bursts. "You'll never get that place cleaned up, never." You could jettison them during an EVA. "Unfortunately, there is only one bag," so you can't throw it away.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Environmental
Issue:	windows fogging
Description:	window fogging with moisture from excessive breathing
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	How often did the windows fog?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Environmental
Issue:	LM cabin
Description:	LM crew reported cabin clean with no loss of bolts or screws
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did you commonly find nuts and bolts floating in cabin of LM?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Environmental
issue:	urination system
Description:	Back pressure in the urination system required straining to overcover the check valve. This resulted in urine remaining in the condom receptacle and no way to dispose of it except to blot it, requiring a lot of blotting. Lots of air bubbles in the sample container, which reduced sample volume The condom which rolled onto the penis for urination, were completely unsatisfactory during flight uses. Discussed at length later in the debriefs.
Comments:	Medical interview changed the subject
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Environmental
Issue:	eating, sanitation
Description:	Must support "human eats on earth", “Human being food," refrigerator, oven, etc. Must support defecation and urination like a human being, whether that means a toilet or some new design, and reduce medical samples of eating, defecation, urination. Must provide showers, clothes These things are essential to longer duration and doing the job "The Apollo is too small. We need to treat a human in space like a human being, and not a guinea pig. Really need hot and cold food
Comments:	Need to be able to clean the body periodically, internally and externally--psychologically improves your outlook:
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Work/Rest Schedule
Issue:	Sleep Observations
Description:	a) Sleep was fitful for the first three nights and last night before re-entry b) Daily cycle shifting for upcoming events (rendezvous, burn, etc.) made sleeping on schedule difficult c) Bring ear plugs, blinders during sleep shift. Also consider having all three CM sleep at same time, or 2 CM sleep and one CM minding the store d) CM went through 5 days with 4-5 hours sleep, felt fatigued throughout the mission: e) "Timeline was terrible". Careful review of the flight plan reveals that the crew was working twelve days in a ten day mission f) Crew slept between 5-7 hours per work day at best
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	1. Sleep cycle shifting? 2. Do the astronauts need to get used to sleeping with ear plugs and Blinders before leaving? If so how long
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	Sleep interrupted by comm
Description:	Can we cover our ears with plugs or something since comm is interrupting sleep of or CM's.
Comments:	
Resolved:	
if Resolved how, when, where?	
Questions:	What countermeasures will we have to help with noise waking crew up while trying to sleep?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Work/Rest Schedule
Issue:	Sleep Observations
Description:	a) Crewmember did not feel the pre-flight sleep period was long enough -was sleepy on launch b) Work / rest cycle could be improved c) Sleep cycle / deprivation affected the crew performance -Average 2 hours continuous sleep (see Comments and Questions) d) Crew preferred being wedged into something to feel secure for sleep Sleep restraint device was outstanding
Comments:	Work / Rest Cycle Suggestions: Simultaneous sleep cycle during landing phase 1. Window cover ups 2. Turn out lights 3. 2 CM in sleep restraint and one asleep with headset on -Ground would not call up except impending gimbal lock or other emergency 4. Ground automatically switch all 4 0MNI antennas Another crewmember gives a good description of the sleep cycle
Resolved:	
If Resolved how, when, where?	
Questions:	How can work/rest cycle be specifically improved? How was crew performance affected by sleep deprivation
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Work/Rest Schedule
Issue:	Crew Rest
Description:	a) Crew Rest b) Crew sleeping locations
Comments:	a) See Questions, below b) Crew slept under the couches, secure.
Resolved:	No
If Resolved how, when, where?	
Questions:	a) Is there something in the space environment that makes you more susceptible to being ill? SURGEON: No CREW: Fatigue from long crew days, poor eating habits, e.g., Rendezvous days was 36 hours only…
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Work/Rest Schedule
Issue:	Sleep Observations
Description:	a) Crew slept simultaneously during the return portion of the mission b) Felt rest time was adequate with all 3 crew members asleep at the same time. -Crew felt there was little work to do on return and could sleep simultaneously without concerns -Wanted to be well rested for re-entry -Crew activities during staggered sleep was disturbing -Crew felt both disconnecting comm hardware
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	On extended missions is simultaneous sleep better than staggered? If so, are the scheduled projects amendable to this?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Work/Rest Schedule
Issue:	Sleep Observations
Description:	a) Crew reports that they slept well in CM on the way out 1. Each CM slept under individual couches and sleeping bag b) Sleep in the LM on the surface was fitful for a number of reasons (2-3 hours most) Noise-glycol pump in LM Lighting Temperature -cold next to floor Lack of comfortable places to sleep Dust accumulation on the floor
Comments:	Temperature problem: Whatever the problem was on the Lunar surface was not anticipated on the ground
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Work/Rest Schedule
Issue:	errors
Description:	general errors in procedure secondary to being tired < 3 hrs of sleep
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	Do we need to set limits on how much sleep is needed to do next day tasks?
Summit Topic:	Yes

Source:	BME logs
Topic:	Work/Rest Schedule
Issue:	HR
Description:	rest did not lower HR
Comments:	Curious finding during lunar timeline: crew HR often were elevated during rest. Why did this occur?
Resolved:	
If Resolved how, when, where?	
Questions:	Were your times of rest on the moon adequate? Did you rest or did you still do things? Was sitting or would sitting be helpful in 1/6 g?
Summit Topic:	Yes

Source:	BME logs
Topic:	Work/Rest Schedule
Issue:	sleep breathing
Description:	Cheyne-stokes breathing with deep sleep
Comments:	understandable due to decrease CO2 decreasing respiratory drive?
Resolved:	No
If Resolved how, when, where?	
Questions:	Is this a normal respiratory phenomenon?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	tracking mistakes
Description:	Crew making mistakes on tracking secondary to lack of sleep?
Comments:	Crew timeline needs to allow more frequent rest periods.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	poor sleep
Description:	Did not sleep well in LM
Comments:	not expounded on
Resolved:	
If Resolved how, when, where?	
Questions:	What caused you not to sleep well?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Work/Rest Schedule

Issue: Sleep, Work & Rest Observations

Description:
a) Crew slept a lot, between 7-10 hours, but described it as a "light sleep. Typically woke early at least 1 hour before schedule
b) LMP would sleep 5 hours, take a sleeper then return to sleep for 3.4 hours
c) Reverse Schedule -crew extended FD1 as long as possible to adjust to reversed day-night flight plan
d) Scheduled 10 hour sleep period were more than adequate
e) Work days were typically 14-15 hours
f) Crew suggests not eating dinner before going to bed. Apparently that is how meals were scheduled in the flight plan
g) Crew felt the work/rest was reasonable, allowed them to accomplish what they needed and rested
h) On the lunar surface, sleep/rest is a minor issue, The busy pace and minimal rest did not effect their limit of efficiency. However, this would become an issue with extended-duration ops.
i) Sleep in the LM on the Lunar Surface was okay.

Comments:

Resolved:

If Resolved how, when, where?

Questions: Did you think you could function/sleep in the LM for > ? days on the lunar surface? Crew seemed to think so

Summit Topic: Yes

Source: Medical Mission Debriefs

Topic: Work/Rest Schedule

Issue: sleep

Description: CMP: slept best with the couch flat, in the sleeping bag (it got cold at night) and pull the straps down. LMP: usually slept 5 hours at end of day, wake up, take a sleeping pill. Without the pill, didn't get back to sleep -- thinking about the flight CMP: Difficulty sleeping on first night, back uncomfortable. CDR: Had no back pain during flight, but for about 4 days post-flight, in the Mobile Quarantine Facility (MQF) was hobbling, secondary to back pain.

Comments: Several CM had back pain during their mission.

Resolved: No

If Resolved how, when, where?

Questions: What in-flight activities relieved back pain severity?

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Work/Rest Schedule
Issue:	Insomnia
Description:	CMP" "...and I was always having a muscle twitch in my legs and –" LMP: "...at that bag parts I had the feeling I was going to ricochet right out of the side of the wall." (missing part of transcript obscure full meaning) "I'd watch him in his sleep, He'd be in there in there sleeping on me in the bag, and boy all of a sudden he'd just shot around and sort of…And every night he'd…and he'd talk sometimes too in his sleep. your really hit those things that – I knew that I know that that's beyond what you normally – "
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	rest
Description:	Dexadrine 2 each to keep awake upon re-entry
Comments:	
Resolved:	Yes
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	mistakes
Description:	mistakes on read back secondary to lack of sleep
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Work/Rest Schedule
Issue:	23hr day
Description:	23hr day crew worked
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Work/Rest Schedule
Issue:	poor sleep
Description:	crew didn't sleep well and ground had to ask for sleep report
Comments:	Poor sleep on the lunar surface multifactorial.
Resolved:	
if Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Work/Rest Schedule
Issue:	Mattress
Description:	Sleep "hard mattress"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Can you explain how the hard mattress makes sleeping in space difficult?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	Cat Naps
Description:	Cat naps were useful for some crewmembers, especially for those who could not get restful sleep during their sleep period
Comments:	
Resolved:	No
If Resolved- how, when, where?	
Questions:	How was this observed HR or EKG? Is this reason for us to adjust schedule?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	sleep
Description:	4 hrs of dozing mostly within the lunar module
Comments:	this was a night before EVA
Resolved:	
If Resolved how, when, where?	
Questions:	Why was it so hard to sleep on lunar surface? Lack of space? Environment? Excitement? Why didn't you take medication?
Summit Topic:	Yes

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Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	light flashes
Description:	Light flashes in eyes of both CDR and LMP 4 hrs of sleep then awakened
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did these light flash experiments interfere with sleep?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	23-24 hr day
Description:	crew sleeping after a busy 23-24hr day
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What causes these long days and what can we do to fix this?
Summit Topic:	Yes

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Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Work/Rest Schedule
Issue:	sleep
Description:	LMP: LMP and CDR" on reserves." CDR: 2nd day out " we weren't really sleeping along too well," we slept better after TEI - probably the best night in terms of continuous sleep. LMP: felt I was on reserves. " I felt very strongly that I was on reserves, that physically I was going down hill. And it was of some concern to me that I wasn't getting enough sleep, "But sleeping to me was a very insecure experience."
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	BME logs
Topic:	Work/Rest Schedule
Issue:	capcom awakens crew
Description:	capcom awakens crew during sleep period with non-essential information.
Comments:	Crew sleep was poor. Inadvertent calls from Capcom or purposeful calls but not necessary need to be stopped.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	tired
Description:	sounds tired?
Comments:	no more explanation
Resolved:	
If Resolved how, when, where?	
Questions:	was being tired a real factor during the mission?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	awaken early
Description:	Crew needs to be awakened early for SC attitude adjustment FS didn't like this but understood and felt one of CM was awake do to HR. FS not asked by flight director
Comments:	
Resolved:	
If Resolved- how, when, where?	
Questions:	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	without suit
Description:	sleeping with suit off is the secret
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Is the best rest without suit, or more beneficial than the time saved/extra time sleeping in the suit?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	lost sleep secondary to TV
Description:	Crew repeatedly disrupted t/c the OSO was very confused about how to get camera to retract. FD disgusted and angry b/c delayed onset of sleep
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How often did PR events get in the way of sleep and the mission? How this problem be combated?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	tired
Description:	"Yesterday we finally got a chance to catch our breath”
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Would missions be more successful if timelines weren’t so hectic?
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	sleep timeline
Description:	sleep timeline not to be disturbed by LM trouble
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	fatigued
Description:	CM became impatient during docking, appears to be fatigued. However criticism justified.
Comments:	See how lack of rest pours out into everything.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	quiet
Description:	asked for quieter shift
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was noise a big problem?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	lack of rest
Description:	crew up for 21 hrs with 9-8 hrs rest "a plan much like Apollo 15"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was it the SC that needed you to be up for 21 hrs or other extra things during the mission?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Work/Rest Schedule
Issue:	problems sleeping
Description:	seconal didn't help
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Work Rest Schedule
Issue:	Sleep
Description:	"sleep better if orients himself to the side" complained of nasal congestion secondary to lunar dust
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Explain this sleep position in detail was the LM well suited for this?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Physiological Function
Issue:	fluid shift
Description:	CMP:P loss of appetite first two days CDR: less fullness of head, etc. than on previous flights. LMP: puffiness underneath eyes and face
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Physiological Function
issue:	sunglasses
Description:	CDR had a headache during first couple of revs in lunar orbit which he attributed to moon gazing. "You need to protect your eyes." Dr. Berry points out the sunglasses are USAF issue N-15 type, neutral density filter, 15% transmission. These have plastic lenses, USAF have glass lenses. While on lunar EVA, this was not a problem Crew did not agree that the sample N-15 sunglasses presented at the debrief were the same as what they flew with.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Physiological Function
Issue:	Vision on the lunar surface
Description:	Can see very well-particularly cross-sun. Not much contrast over large distances, difficult to discern horizon sometimes. Very bright looking into the sun, lots of glare. Initially going into a shadow it takes about 15 seconds for vision to accommodate, after that accommodation improves, but out of the shadow is so bright LMP doubts full reduced lighting accommodation occurred. Could see into craters "pretty well." Intermittently used the outer visor, used mostly when looking into the direction of the sun. No particular problems expressed.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Physiological Function
Issue:	upper body fullness
Description:	Had noticeable facial fullness on the first day of zero-g. "It's just like you're standing on your head." Resolved after about 24 hours. Had blood-shot eyes the first day.
Comments:	
Resolved:	Yes
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Physiological Sleep
Issue:	Function
Description:	Averaging about 5-7 hr sleep, Thinks 6 hours per night is sufficient CDR disagreed thought 6 hours per night would not be enough for more than a week or two
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Human Factors
Issue:	naps on watch
Description:	suspected several naps on watch
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How will we crew get better sleep during sleep time so they stay awake during watch? What can we do to help them stay awake on watch?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Human Factors
Issue:	Radiation
Description:	a) This crew had more radiation exposure than previous Apollo missions due to trajectory -the course through the VA belts exposed them to major radiation on the way to the Moon. -estimated to be about 2 times the radiation exposure of Apollo 8 (7,9 were LEO) -570 mrads's or 0.57 rads b) Estimate of exposure from SPE will be approximately 400 rads skin dose and 50 rads dep the dose = lunar surface exposure
Comments:	COMPARISON: Head x-ray 82-220 mrad's Leg x-ray 440 mrad's Arm x-ray 127 mrad's GI series 790 mrad's Dental 16,380 mrad's
Resolved:	
If Resolved how, when, where?	
Questions:	1. Do we have a plan to control radiation exposure for longer lunar missions where radiation exposure is higher to begin?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Human Factors
Issue:	Post Flight Quarantine
Description:	a) Pre-flight exposure to illness is critical to post-flight condition to ensure that any post-flight illness was not due to lunar exposure b) It is critical in the preflight period to allow the crew to slow down in the schedule so as not to lower their resistance to infection, c) It will be difficult to ascertain if either this was some latent infection, pre-flight exposure, or lunar exposure
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Should pre-flight quarantine be longer than current 7 days on a longer mission? Should this be 21 days instead? If it should be longer, should crew be quarantined with family to help with mental downside to isolation? If so, should family be removed from quarantine 1 week prior to so crew can mentally prepare
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Human Factors
Issue:	Crew Health and Performance
Description:	a) During DF 0-2, and last 3 days, coming home the crew kept occupied. But in between they felt they had nothing to do. -Wish they had brought recreation materials along: Books, music b) CMP felt that he was responsible for the state the ship during the transit time; that the activity was his and LMP could relax during the transit, but he was always on task c) CMF was concerned by the flight plan change after the Lunar landing had a CM been at the end of his work day – and he was very tired. Probably not a good idea. d) Crew recommended doing something to keep the CMP occupied -Comm helps tremendously, especially briefs on every events -MSFN relay was the best thing CMP had -Crew Suggest for long duration mission wake the SC environment as normal as it is down on Earth (similar to F. Hansen's experience)
Comments:	Crew health and performance issues during TLC and TEC are key issues for all missions to consider.
Resolved:	No
If Resolved how, when, where?	
Questions:	How do you help the crew mentally and physically prepare for 20-24 hour work days?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs/Apollo Lecture Series Program

Topic: Human Factors

Issue: Lunar Surface Operations, Mission Ops

Description: Crewmember Observations from debriefs

1. Mission objective was to make contact with Surveyor spacecraft launched approximately February 1967 -need to demonstrate ability to land at a chosen destination
2. "Leadership" was what enabled the Apollo team to accomplish its goals.
3. NASA should let people know that space travel is a dangerous business. When you are at the Earth's edge of technology, exploration is a dangerous business
   i.e., Magellan started with 240 males and 3 ships; they returned 3 years later with 26 males. Magellan was killed in the Philippines
   150 people die/day in auto accident. No one stops driving their car
4. Space suit worked well with the exception of the glove, lack of waist mobility.
5. First few moments after stepping on the moon, make sure you hold onto the handrail for balance. The first couple of moments are pretty wobbly. It takes 3 minutes
6. Look ahead at the ground to be able to visualize craters and boulders. Otherwise, it is possible to trip on a rock. You cannot visualize your feet in the helmet.
7. Rocks existed under the surface dust. easy to trip and fall. The surface is not uniform
8. Lunar Resources Apollo 12 Preliminary Surface Report
   Crew observations and experiments
   -Apollo 12 technical report debrief
   -Give Kranz book
   -Neil Armstrong book

*Confidence comes from reading these reports.

9. Do not re-design lunar tools. They worked for the jobs that had to be performed
10. Hand got tired early from picking up rocks. Re-design gloves.
11. Lunar dust is like ground down lead. Similar to the grindings in a pencil sharpener.
    -"tenacious" made zipper sticky
12. Suit cooled off quickly, efficiently
13. Moon is not magnetic - compass would not work. Never had a gyroscope navigation system
14. Support from the space program will come from appealing to middle -America
    e,g., Al Shephard hitting the golf ball; Scott dropping banana and feathers to demonstrate Galileo's principles
    * Do things on the moon that connect and are of interest to folks on the Earth
15. Volume of the LM was never a problem
16. Don’t solve problems that aren't really problems, e.g., lunar boots
17. No health related issues with the Lunar dust
18. Lighting in the SC was adequate
19. Earthlight was noticeable, a pretty blue
20. Rover did not have headlamp and shouldn't
    -Going into a dark crater a shadow is a bad idea
21. Apollo 12 did not have any contingency plan for a SPE on the surface
22. Exercise countermeasures capability for short moon (1/6 g} should be limited
23. Being a good team member is appreciated/admire the other team members (Pete Conrad)

Comments:

Resolved:

If Resolved how, when, where?

Questions: 1. Are suits designed to withstand inevitable falls? Is there a backup safety device to the suit in case of falls that may harm suit? 2. Would packs be useful on lunar surface, would they improve hopping or slow it down?

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical

Topic: Human Factors

Issue: Isolation of CMP during Lunar Ops phase

Description: CMP: “You know, it's not too far removed from the prison camp environment. You're stuck up there alone and you're by yourself, you sit and contemplate your own damn misery, and you're out there so damn far away from everything else it could have conceivably been a problem.”

CDR: "These CMP fellows on 28-day missions and things like that are really going to need that recreation. I never pushed for it when I was working CMP, but, boy, right now I'd be in there hustling to get some good music and good tape recorders and some books,..that 28 days is going to be a long, long time."

CDR: "..the happiest I saw CMP in a long time was the day we got back up to the command module.
We got in that.., and closed the door and he was so happy, he was dancing and jumping around,"
CMP: "It was amazing to me, I was really happy.*

Comments:

Resolved:

If Resolved how, when, where?

Additional How can the environment be improved within the vehicle limitation for mass and volume?

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Human Factors
Issue:	Books
Description:	CMP: "We were just going to flat smuggle in paper back books put them in our suit pockets." Unidentified: "I've said it every goddamn time after the first flight that I went on, I was a dumb ass for not taking a book." All crewmembers thought reading would help relax them and help them get to sleep quicker. LMP: particularly important for the CMP who is alone for 3 days. He needs his relax time, all need relax time. And the CMP pilot needs to be occupied
Comments:	Recreational activities/equipment is a request made by most CM.
Resolved:	N/A
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Human Factors
Issue:	Change in activities
Description:	LMP: The CMP had a very long day, doing similar tasks for nearly 24 hours. The lunar surface crew had a major change in activity after beginning descent to the moon surface, "We did the flying part of the work, and at kind of the end it was almost a celebration after 5 days of sitting in that spacecraft, to get outside and walk around and move your arms and do a little work, it was like going out and playing golf or playing tennis. It was a big change from the other kind of work and it was damn enjoyable."
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Human Factors

Issue: circadian shift after launch

Description: LMP: Felt staying up as long as possible the first flight day helped do the diurnal reversal. Ten hour sleep periods were more than adequate -used some of the time the chat in the evenings, do housekeeping functions, etc. Working hours were long.

CDR: Lost track of all Earth time." Got on our own cycle." They were motivated to work on the lunar surface after all the work and training that preceded the actual mission. Didn't want to spend lunar time sleeping.

LMP: during lunar stay, sleep was impaired by the discomfort of the suit --should sleep without the suit.

CMP: was very tired the first night in orbit because of the long day, which was close to 24 hours.

LMP: "... I think you ought to get the guys out of the suit, and you ought to give them a man's blanket, if that Beta cloth Mickey Mouse thing they killed us with, if I'd have slept in that it wouldn't have worked, but if you gave a guy a good roll blanket I couldnt've really slept in that LM if I hadn't been so uncomfortable in my suit." "I'm sure that I would have slept a good 7 hours had I not been uncomfortable in the suit.., if it hadn't been screwed to my shoulders like it was."

CMP: had to do a plane-change burn just prior to going to bed, resulted in a very long day for the CMP "I knew I was hanging on the ragged edge for being tired." "I was so much over tired that I couldn't go to sleep right away." "always having the muscle twitches in my legs" Dr Berry: "It was close to 24 hours."

Comments:

Resolved: No

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Source: Flight Surgeon logs

Topic: Human Factors

Issue: prelaunch quarantine

Description: Dr. Jernigan notify FS MOCR that a contractor suit technician had acute gastroenteritis and failed to report this. Was not in contact with crew but handle suit.

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Human Factors
Issue:	ALSEP/ Lunar Surface Ops
Description:	ALSEP equip heavier than expected
Comments:	
Resolved:	
if Resolved how, when, where?	
Questions:	Why was it heavier than expected ? Was training not adequate for 1/6G? Should we prepare differently?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Human Factors
Issue:	pressure misread
Description:	believed crew originally misread change pressure gauge but venting was done right so probably more O2 rich than ever
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions: Questions:	what makes them think crew misread gauge?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Human Factors
Issue:	increased HR
Description:	Increased HR with thruster firings
Comments:	Noticed this in earlier missions as well
Resolved:	
If Resolved how, when, where?	
Questions:	How irritating was thruster firing to sleep?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Human Factors
Issue:	mistakes
Description:	stated made mistake secondary to numerous flight plan changes
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Related to heavy timeline activities?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Human Factors
Issue:	forgot to change LiOH canister
Description:	forgot to change LiOH canister
Comments:	
Resolved:	
if Resolved how, when, where?	
Questions:	Was the LIOH canisters a hassle?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Behavioral health and performance
Issue:	mental health
Description:	"We appeared to be 100% concerned about the physical welfare of the crew and physical data we get back and little or no concern about the mental welfare and the mental well being of the crew and taking account little or not at all those agonizing, frustrating, many things that get on people's nerves whether they be urine drops floating in someone's eyeball or whether they be cutting extra pieces of Velcro off to be able to save food or handling garbage or whatever it may be. And these are things we've got to consider. Mental welfare, to me, fits hand in hand with the physical welfare, and until we begin to realistically consider all those factors then I think we've got a long way to go in space flight."
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	

Source:	Medical Mission Debriefs
Topic:	Human Factors
Issue:	sleep
Description:	CDR -initially preferred head support and no arm floating IMP -no problem with positioning CMP -difficulty awakening and getting going after sleep
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Exercise
Issue:	Exercise/Observations .
Description:	a) Started Day FD2 b) 45 min/day c) Types of exercise: 1. Feet in stirrups –straighten out 2. Arch back with feet in stirrups 3. Minimal arm exercises. 4. Ergometer. 5. Power lifting while on the bike
Comments:	1.Recommend no specific time schedule - just do it on your own 2. Markedly improved back pain/ankle pain 3. Equipment 4. Stretching 1 .Post-landing “Achilles tendon was tight, needed period of time to readjust” 5. Positioning 1. Fetal position is position of comfort
Resolved:	No
If Resolved how, when, where?	Improved (back pain/ankle pain)
Questions:	1. The Big Four? 2. Pulse rate never got up with exercise: CMP approximately 105 BPM @ 177 +50 3. Exercise could use some improvements. Concern about the exergenie wearing out?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	exerciser broke
Description:	“Crewmember broke the Apollo exer-genie with use.”
Comments:	Device was frail, could not withstand frequent use
Resolved:	No
If Resolved how, when, where?	
Questions:	How long is the exercise equipment slated to last on an exploration mission?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Exercise
Issue:	Equipment and Technique
Description:	a) The exercise device (cycle ergometer) got real hot during use. Crew describes it getting "dangerously hot". Even before CM got tired of using it. Unable to touch device or store it safely secondary to heat accumulation b) Crew felt having an exercise device, especially last 5 days of mission was beneficial for return to gravity c) Crew felt just tensing leg muscles against same resistance (pushing against bottom of "LEB") was helpful.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Is cycle ergometer the same design as the one that will be used in future or presently?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Exercise
Issue:	Exercise Observations
Description:	a) LMP got his heart rate up to 177 bpm using the exer-genie 1. Apparently moving arms/legs against the device before it got too hot. 2. Used parts of the CM -"struts" 3. Ran in place in couch.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What phase of the mission was the exerciser used?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Exercise
Issue:	increase HR
Description:	Increased HR during exercise
Comments:	Did the exercise activity provide any cardiovascular benefit? Observed HR were below anticipated CV threshold
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	BME logs
Topic:	Exercise
Issue:	exercise
Description:	Exercise pulled biomed cable loose
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How and why did exercise pull the biomed cable loose?
Summit Topic:	Yes

Source:	BME logs
Topic:	Exercise
Issue:	exercise
Description:	Crew exercise reported as mild. Unable to get HR up with devices.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How do you determine mild exercise based on perceived exertion? Or HR?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Exercise
Issue:	Exercise Observations
Description:	HR never approached the rates observed in 1 g in the gym
Comments:	
Resolved:	N/A
If Resolved how, when, where?	
Questions:	How important is it to exercise effort short-duration (<14 days) lunar missions? -if it is, what is the goal exercise countermeasures (e.g., CV tone, neurovest, postural tone, etc)
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Exercise
Issue:	heart rate during exercise
Description:	CMP: never got over 90, but we limited to avoid perspiring CDR: got to 120 'guess I got lazy or something. Worked as hard as he wanted to and the rate would be about 120.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What was the thermal/condensation load limiting perspiration with exercise?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	exercise
Description:	LMP may be on exerciser but HR not very high
Comments:	Crew unable to generate elevated HR because of limitations of device and concern for 100% O2 environment.
Resolved:	
If Resolved how, when, where?	
Questions:	What makes us think we were on exercise not on Biomed monitor?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	exercise
Description:	may be exercising
Comments:	FS didn't know when or how long and to what intensity the crew exercised.
Resolved:	No
If Resolved- how, when, where?	
Questions:	We won’t have much room in CEV will we have enough for any of the current exercise devices?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Exercise
Issue:	debrief of individual exercise regimens
Description:	CDR: his goal was a 10 minute period daily, exclusive of the 2-day lunar surface activity, for both he and the LMP. The CMP was to do that exercise each day. The Exer-gym was to be used, beginning with 1) legs with feet in the two loops and hands controlling the friction device, from a crouch to a full stretch-out. Then 2) hold the fixed loops and use the legs on the movable loops, then 31 hold the fixed loop with the toes and use the biceps and movable loops. These exercises designed to work the "Big 4." Did not exercise the first day out. While it is in the flight plan, the day is too busy. CDR expressed opinion that the contribution of the 10 minute exercise pedods was "down in the noise level" compared to the basic workload of the 30 hours of work on the lunar surface, including the EVAs. When Dr. Berry said "you don't really need it on that first day anyway," LMP differed, suggesting it "would probably have alleviated some of the sore back muscles that first day if we had gone ahead and done it, in my case, anyhow." CDR specified exercise prior to lunch every day as the most efficient schedule time.
Comments:	LMP limited exercise intensity to just below generating a sweat, felt heart rate increase and increased respiration, but "it's not a vigorous exercise, more of a tension exercise." Did a hard, slow pull.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Exercise
Issue:	exercise routine
Description:	CDR: goal was about 10 minutes per day exercise for lunar surface activity days for the CDR and LMP. For CMP, ten minutes each day. Planned to use the Exer-genie device. Missed the first day out -not on schedule, LMP thought first day exercise might have helped avoid his sore back muscles the first day. LMP felt he increased his heart rate and breathing rate --tried to avoid "cracking a sweat." CMP didn't work up a sweat -exercised 5-10 minutes per day, CDR: benefit of exercise "was down in the noise level for the CDR and LMP."
Comments:	
Resolved:	N/A
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Exercise
Issue:	Description of CMP rout
Description:	Perhaps 5-10 minutes at lowest level. “finally got around to getting it and doing some exercise on it." Missed one day on the way out and did not exercise at all in lunar orbit. "Barely got in the one exercise a day that we did on the way home. “Didn’t hit the Exer-gym as much as I probably should have." The work schedule did not permit much exercise time.
Comments:	Crew schedule did not provide formal exercise time.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Exercise
Issue:	no data
Description:	no data during exercise period
Comments:	Crews were not connected to Biomed data port during exercise.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Exercise
Description:	all exercising off line
Comments:	Crews were not connected to Biomed data port during exercise.
Resolved:	
If Resolved how, when, where?	
Questions:	If they are offline and exercising how does that help us?
Summit Topic:	No

Source:	BME logs
Topic:	Exercise
Issue:	possible exercise
Description:	LMP thought to be exercising but instead trying to open crew compartment because of increase in thermal/humidity in cabin environment.
Comments:	
Resolved:	
If Resolved how, when, where?	
Additional	How hard was it trying to get into compartments? Do they need to be more user friendly?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	exercise
Description:	crew reports exercise though no increase in HR
Comments:	Crews were limited by poor exercise capability and concern over impacts (100% O2).
Resolved:	
If Resolved how, when, where?	
Questions:	Do you know what types of exercise increased HR and what types didn't?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	exercise hunger
Description:	after exercise I ate every morsel of food allotted
Comments:	
Resolved:	Unknown
If Resolved how, when, where?	
Questions:	Do you need to have snacks? Do you feel you would eat more if you exercised more?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	loose sensors
Description:	exercising with HR120 EKG sensors became loose during this activity
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Are the biomed sensors most needed during activity or rest?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Exercise

Issue: how much

Description: CMP: first 3 days worked with the Exer-genie, 3 periods every 2 days, maybe. Each period 15 or 20 minutes. In lunar orbit, 2 periods a day, 10-15 min of each spent running in place, using the center couch. And 5-10 min of each period working with the Exer-genie for a total of 20-30 minutes, 2 periods a day. Used 'straight' exercise with the Exer-genie. Not much increase in heart rate with the Exer-genie, but more with the running.

CDR and CMP neither could get heart rate over 80 with the Exer-genie.

No exercise after the EVAs or on way home. Too busy cleaning up and stowing.

CDR: exercised once a day on the way out, using the Exer-genie until it appeared to wear out. Did deep knee bends with feet against the bulkhead, hands against the struts and pushed against his arms. Pull up to about 100 with that. Exercise period about 5 minutes.

LMP: Exer-genie once daily for maybe 10 minutes on way out, on the way back strained against the seat restraint until it failed.

Comments: A bungee to the floor for running in place would help, they thought

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Source: Medical Mission Debriefs

Topic: Exercise

Issue: sweating

Description: CDR: never sweated except when running in place after about 10-12 minutes, and in gloves after EVA

LMP: after EVA-1 noticed gloves were wet from sweat

CDR: after an EVA drank directly from the water gun, was very thirsty and after EVA drank until satisfied.

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	exercise
Description:	exercise period
Comments:	no information on exercise
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Exercise
issue:	exercise
Description:	exercising but no HR due to bad sensor
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Exercise
Issue:	exercise
Description:	began exercise HR 90-140 recovered in 2-3 min HR 60 BPM “running in place holding on to couch"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	was this an effective or rewarding method of exercise?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	increased HR
Description:	HR increased most likely exercising
Comments:	very little documentation on exercising in Apollo.
Resolved:	Unknown
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	exercise
Description:	exercise HR 125 then fell below 80 in 1 min
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	exercise
Description:	running in place HR 130 for 1 min exercise unspecified for 4 min average HR
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What were the limitations to exercise?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	exercise
Description:	exercise pre 65 average 115 HR max 140 exercise stopped secondary to shaking gyro O2
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What kind of exercise was done that caused shaking gyro?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	exercise
Description:	During exercise 25 psi dead band went to 3 psi dead band?
Comments:	hard to read confused on what was said
Resolved:	
If Resolved how, when, where?	
Questions:	What problems with the hardware was noted while exercise?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Exercise
Issue:	max HR
Description:	exercising Max HR 115
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	what exercises did you feel strengthened you the most which ones increased HR the most?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	Delete H2O Chlorination
Description:	Chlorine limit is 5ppm but cannot be confirm by taste, as Chlorine does not mix uniformly throughout tank. Will discard the first 5 clicks of H2O before taste
Comments:	Secondary to overwhelming chlorine amount in solution.
Resolved:	
If Resolved how, when, where?	
Questions:	Will Chlorine used in the Apollo era be used for exploration vehicles or newer Iodine for potable water sterilization?
Summit Topic:	Yes

Source:	BME logs
Topic:	Food/Nutrition
Issue:	H2O
Description:	H2O smells like a bucket of Clorox
Comments:	Related to inability to adequately stir chlorine in the water tanks after application.
Resolved:	
If Resolved how, when, where?	
Questions:	If we use iodine instead of chlorine will we run into the same problems with a different smell?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Food/Nutrition
Issue:	potable H2O tank
Description:	Potable H2O tank quantity decrease possible rupture?
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did the potable water tank rupture? Or has it ever? Do we have a back up if it does? Can we repair it if it does?
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	Crew Preferences & Observations
Description:	a) Variety is more important than getting what you like. They were on a 4 day rotation b) Avoid high calorie foods –unclear why this is the case. Apparently these food types were packed because of the mass-power-volume issues c) Food items (beef, chicken sandwich) was “crumbly" -quite a bit of crumbs in the cockpit d) Orange juice, clam chowder package broke or split. Crew prefers the soup e) Ham & applesauce “grew thick”
Comments:	Specific Food Notations: 1. Pudding, cookies sweet cinnamon toast, chocolate drinks, heavily sweetened fruit drinks 2. Meat dishes were desirable, especially bacon squares 3. CM believe they would have gotten more total calories if lighter foods were available 4. Cut down total calories from 2,500/day to 2000 -2200 day 5. Choose more dehydrated foods and less bite-sized foods. Crew got sick of them towards the end of the mission 6. The H2O gun was very hard to operate -got stuck often. Also heavy Chlorine taste secondary to inadequate stirring after ever 12 hours of application.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	H2O smells like a bucket of Clorox
Description:	Cont. problems with Chlorination
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	Crew Preferences and Observations
Description:	a) Food was mediocre in taste -tasted the same b) Crew avoided the "bite food". Either too sweet or too dry -Two crewmembers much preferred the food on Gemini VII / XII -Exception was the Christmas dinner -turkey was good -Shrimp cocktail was delicious c) Preparation of food: unclear how certain foods were prepared d) Crew wanted between meal drinks (not H2O) e) Grape juice was OK Orange juice was poor Banana pudding was poor (tastes like airplane dope) Coffee was not good
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How were foods prepared?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	water sample in LM
Description:	LM water sample had Iodine content of 2.3 ppm with microorganism isolated. Filter gun will have to be used.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was Iodine used instead of chlorine? What are the ranges of acceptable iodine? How do we plan on keeping water supply from being contaminated?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	Getting back to eating
Description:	"Now that we have completed our work we are back to eating again?"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What about your work kept you from eating?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
issue:	Food
Description:	a) Fruit cocktail / peaches were really good b) gas bubbles form in the food bags and were difficult to remove. (see Questions)
Comments:	Crew described it as distasteful to have a bag full of bubbles intermixed with food or "liquid. It was difficult to "burp". You felt blocked with no mechanism to relieve it.
Resolved:	
If Resolved how, when, where?	
Questions:	Why was this a problem? Could something simple like gas x prevent this problem?
Summit Topic:	Yes

Source:	BME logs
Topic:	Food/Nutrition
Issue:	water/H2
Description:	"I took 8 gulps of water 4 of which were air"
Comments:	This sums up the problem nicely
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Food/Nutrition
Issue:	water/H2 separator
Description:	Centrifugal water/H2 separation does not work. Bubbles in to Distal end and coalesce but there is no way to separate gas.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Will we be using the same water/H2 separator? What is currently used on shuttle/ISS? What will be needed with purification system we will use?
Summit Topic:	Yes

Source:	BME logs
Topic:	Food/Nutrition
Issue:	8+ hours without eating
Description:	"Just now getting around to eating"
Comments:	This was documented at 8:33
Resolved:	
If Resolved how, when, where?	
Questions:	How was eating scheduled? Was scheduled eating time pushed aside because other things needed to be done?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	Hydrogen gas reported in water
Description:	Hydrogen gas reported in water
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	Does this currently still happen?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	Food Preferences and Observations
Description:	a) The crew mixed H2O with grape juice to kill the awful chlorine taste in the water b) Stomach fullness from the gas in the water and busy mission schedule precluded 3 meals per day. Crew averaged an a.m. and p.m. meal, however, rarely felt hungry. Exception was rendezvous day where they had gone approximately ?? hours between meals c) “Meat Stick” – Turkey and gravy, dried fruits were well-liked by the Crew d) Plain bread was preferred over rye without condiments. Rye seeds took on peculiar odor e) Fruit preparation was also well-liked f) Food preparations was cumbersome. Crew preferred the food packs with great-beef stew, chicken & rice. Also, food delivery was an issue. Eating spaghetti and meatballs out of a tube was not desirable g) Once food was prepared, the lack of availability of useful areas to store water, food packs, etc., made eating difficult, i.e., each packet had to be finished otherwise, it would float away...one crewmember stated "you have no place to put it" h) Boiling point of water at 5.0 psi is 154 degrees Fahrenheit plus or minus 4 degrees-Steam in water contributed to gas problem i) Crew recommended for Apollo to have many wet pack meal readily available and vacuum seal items like bread, snack, etc. Benefit = ready made, no prep time and easily available.
Comments:	Crew was unsure secondary to lack of sensation of hunger secondary to gas in stomach from the water. Also they felt that physically they weren't working that hard.
Resolved:	
If Resolved how, when, where?	
Questions:	a) What does the crew feel the demands are with regards to eating / calories in? b) There is a question about a mistake that shouldn't have happened, but details are unclear c) Also with juice, some sort of filter as it is consumed to prevent bubble formation
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	chlorination procedures
Description:	LMP: crew were given incorrect instruction for chlorination of water, resulting in the chlorine solution not getting out of the tubing and into the water tank. CDR: The water tanks was the most annoying thing on the whole flight. “it’s ridiculous.” “ my stomach was too distended to drink sufficient water and eat normally. CDR: Never felt hungry during flight, except after transition docking TLI because of no opportunity for meal. IMP: once or twice during the mission felt stomach was hungry.
Comments:	Water system was bad
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	BME logs
Topic:	Food/Nutrition
Issue:	taste
Description:	CMP states does not like food
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	what more specifically did you not like about the food? How have these issues been addressed in shuttle and ISS? What are the plans for CEV?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Food/Nutrition
Issue:	coffee temp
Description:	crew reports cabin temp in 60's and hot coffee in only warm
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	water bags
Description:	Too much restriction to flow on water bags
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	So we have fixed the gas in the water but created a new problem? Is this an improvement or just a change of big problems?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	Crew Observations
Description:	Food was outstanding
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Food/Nutrition
Issue:	scale
Description:	scale nut came off but got it back on
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What if the nut was lost could we replace it? How would this effect the mission?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	can they keep food
Description:	Concern of a crewmember having FD1 nights tuna fish and may be sick
Comments:	turned out he didn't eat the tuna
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	scale broke
Description:	Scale used to weigh the feed water quantities broke "the nut on the top came off"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	water
Description:	water is the same with and without filter
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Explain same? Did it taste the same or same temp? do you think this indicates the filter wasn't working?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	water filter
Description:	Concern of water gun filter by crew-filter taken off
Comments:	Fear of filter be contaminated? It was alluded to but not directly said?
Resolved:	
If Resolved how, when, where?	
Questions:	What caused you to question the filter on the flight and not before?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	appetite
Description:	CDR: Lost 8 pounds on *Gemini 11* and 2 pounds on Apollo 12. "I ate everything in sight and it tasted great. I ate everything in the LM, and I ate all the (LMP) food, he wouldn't eat it. I ate everything." LMP: drank a lot of water on lunar surface, drank and ate less after that. "Powered down on the way home." Very little required activity on the way back to Earth --slept a lot.
Comments:	Appetite among CM was highly variable, but general all CM, with one exception, lost weight.
Resolved:	N/A
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	Water
Description:	Cold water did not have excessive bubbles, but hot water did.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	food usage
Description:	use foods that don't need rehydrating so as to conserve water
Comments:	Crew had to ration H2O during missions.
Resolved:	
If Resolved how, when, where?	
Questions:	Was H2O conservation a problem?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	last nights food
Description:	About eating last night’s half can of tuna already opened?
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did you have enough food that you could snack on if you were hungry outside of meal times?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Food/Nutrition

Issue: Food packaging

Description: CMP: Available time was more a determinant of eating than was the societal factor of other crew eating at the same time. During the transit to the moon, there is more time for eating than in lunar orbit, when there is very little time, particularly when one needs to troubleshoot equipment, etc.

One can get to canned packs quickly and so that's what you eat when you are in a hurry, rather than re-hydrated packs.

CMP lost ten pounds while remainder of crew lost about 1 pound each. CMP attributed his weight loss during mission to a poor diet the last few weeks prior to launch, when he drank 2-3 beers in the evenings.

CDR: compared the food intake with the activity level -- when activity level is high, "wet packs and cans" is all you have time for. Food preparation could be time consuming, limiting consumption during high activity times.

CMP: all bite-sized packages were consumed -"that was the best thing we had." Tasty and quick. "You just flip that off and a can of juice, and you could go at it."

Comments:

Resolved: No

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Source: Medical Mission Debriefs

Topic: Food/Nutrition

Issue: water and juice consumption

Description: LMP: drank from water gun "every time I went past it." Consciously pushing fluid intake. Preferred juices to water, although water tasted fine, too. Usually drank two juices a meal.

CDR: "decided I was going to do everything I could to end up in as good shape as I could at the end of the mission, which included keeping the fluid intake and the food intake up as well as the exercise."

Comments:

Resolved: No

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Food/Nutrition
Issue:	leak
Description:	leak around chlorine in let port of same problem as was FS logs
Comments:	same problem as was FS logs
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	another leak
Description:	another leak around chlorination port
Comments:	second verse same as the first
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	water loss
Description:	½ 1bs of water lost during leak-mission/problem debrief
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	are we so close on water that this loss would cause a problem?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	water sep Alarm
Description:	water separation alarm then action was taken by switched to H2O sep #2
Comments:	
Resolved:	
if Resolved how, when, where?	
Questions:	What exactly was the alarm and the problem?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	water
Description:	out of water 2 hours to go in EVA
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Should we have more than enough water than not enough water? Did lack of water affect your performance on the mission?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	loose water in LM
Description:	Possibly 3 gallons of water loose in LM cabin b/c of leak in drink gun-problem debrief
Comments:	
Resolved:	Yes
If Resolved how, when, where?	
Questions:	Has drinking gun been improved or how could it be improved?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	Filter
Description:	Bacterological filter broke. Crewmember says feels iodine levels and decay levels adequate therefore filter not necessary in this case
Comments:	
Resolved:	Unknown
If Resolved how, when, where?	
Questions:	Now did we fix the filter so it didn't break again? What caused it to break?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	exhaustion of water
Description:	
Comments:	near exhaustion of feed water
Resolved:	
If Resolved how, when, where?	
Questions:	Should we have more than enough water or just barely enough water?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	not enough food in the LM
Description:	CDR and LMP stated there was not enough food in the LM and that scheduled meals every 10 hours was not enough. They drank and ate everything that was available in the LM
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	BME logs
Topic:	Food/Nutrition
Issue:	CI ampule
Description:	Chlorine ampule didn't go in right, in taking out water bubbled out. Everyone thinks it’s an old problem, Debating what to do should they stay up another hour
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was this an old problem, if so how can we fix it so it stops?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	Potassium intake
Description:	Potassium intake has been low and would like for you to be sure to increase your juice intake but concerned how crew will react to this so just ask them to drink more juice
Comments:	Crew required to take 130meq uCl/day which caused loose stools.
Resolved:	
If Resolved how, when, where?	
Questions:	How should we approach nutrition issues with a exploration crew?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	food bags
Description:	one of the food bags didn't hold its vacuum
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	big meals
Description:	meals are big "could feed a roman army"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Were the meals big because you weren’t as hungry or because they were big? Would you like more smaller meals?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	Increased water consumption
Description:	crews consumption up markedly 8 Ibs above
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Should crews have plenty of excess water? Did you feel you were drinking a lot?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	didn't eat lunch
Description:	didn't have time to eat lunch during high mission activities such as rendezvous, docking, etc.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did, you often not have time for lunch or was this just a busy time with things taking too long?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	water gun
Description:	drink gun leaked during TLC test possible improper procedure? If tried during TEC? Was set screw out during insertion?
Comments:	
Resolved:	No
If Resolved-how, when, where?	
Questions:	Was the drink gun a huge hassle? Did the drink gun interfere with you drinking as much as you would have if it worked right?
Summit Topic:	Yes

Source:	Flight Surgeon togs
Topic:	Food/Nutrition
Issue:	rationing
Description:	limited supply on OJ and other drinks therefore ration them
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did you run out of things you liked? How do we combat this with an exploration mission?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	in suit drink
Description:	consumed all of their in suit drink early during lunar EVA.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What if there was reason you needed to bout longer, would you have been hampered by not enough drink?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	water air separator
Description:	A cigar shaped item, presumably a water-gas separator, made of plastic, leaked secondary to a crack and could not be used. CMP points out it was never tested in the spacecraft preflight, which was a violation of procedures. Item is not described in the text sufficiently to identify it.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	in-suit water bag
Description:	The in-suit water bag cannot be inserted after the suit is donned –must be inserted prior to donning. CDR was therefore unable to drink during EVA truncated discussion about “eating” in the suit. LMP: had free orange juice in his suit. Bag was squeezed between his chest and the suit, the microphone Orange juice floated under the comm carrier, down the mike boom, onto the visor “and it went just everywhere.” Each time the astronaut bend forward, orange juice leaked out into the suit. Bag can be vented in 1/6 gravity, but leaks through the vent hold in zero gravity and can't be vented.
Comments:	CDR and LMP suggested a “stopper in there”, "like those Skylab things."
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Food/Nutrition

Issue: 14.7 psi canned peaches

Description: "anything (packaged) in 14 psi is a mistake in a spacecraft."
These were packaged for Skylab but flow in the 5.0 psia Apollo CM.
"If I had had any indication that there was anything above 5 psi in those cans, I would never have let those things off the ground."
CMP: "If I were an octopus, I'd be a fine candidate for this program. But to eat my meal I've got to have too many hands."

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Source: Medical Mission Debriefs

Topic: Food/Nutrition

Issue: food packaging

Description: "Those cans are a hazard. You tear the lids off those things and that's like a knife just floating around the spacecraft."
Speaker observed opening cans which are sitting on a tray. A tray was not part of Apollo.
After use, a germicide pill was placed in the can. CMP discarded the whole thing in a fecal bag. Once a can or package was opened, the entire contents had to be eaten because there was no way to dispose of partial contents, which could float throughoutt the cabin if not properly stowed. Liquids which were conductive posed electrical threats for shorting out circuits. Can tops posed a laceration threat, Crumbs posed an ocular foreign body threat. Multiple items could not be manually controlled in zero-g during the eating process. After eating, the small, compressed volume of packaging is now a much larger volume, no longer compressed and fitted into a container. A trash compactor is needed. Used food packaging was wrapped and taped into a ball which was stored in a jettison bag. The planned trash stowage volume was rapidly exceeded.

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	food packaging
Description:	If soup was not “thick” it tended to move up the liner package edge and out, moving down the outside. Air bubble in fact tended to be in the middle with no way to remove it. Concern about electrical conductivity of soups, etc., getting on wiring in the CM Beverage packages leaked around the valve Defective heat sealing of cocoa bags, which ruptured when filling with the water gun was attempted.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	food bags
Description:	food bags "blown up"
Comments:	Trapped air expanded during
Resolved:	
If Resolved how, when, where?	
Questions:	what caused the food bags to blow up?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	restraints
Description:	some trouble with food restraints
Comments:	no further explanation
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	better intake with juice bags
Description:	reported slightly better intake with juice bags than water
Comments:	Juice killed the awful chlorine taste that crews were subject to in the H2O system.
Resolved:	
If Resolved how, when, where?	
Questions:	Would you have better fluid intake with juices than just water?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	inlet problem
Description:	inlet valve problem couldn't transfer cold water to sample bottle
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	was this a common problem?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Food/Nutrition
Issue:	water taste
Description:	potable water bad taste b/c rubber hose between ship and SML's
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did water taste like drinking through rubber hose? The CEV design crew should be cognizant of this point
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	drinking water from water system
Description:	crew cut off the 'fill' end, filled the juice container with water, then put the water bag nozzle or valve into that and drank --less messy, could turn it off when you wanted. Far superior (page 18) Bags were very successful, no leaking valve
Comments:	very much liked fresh canned fruit, need to provide way to open without contents escaping initially
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	FD GI discomfort and poor appetite
Description:	Little appetite FD-1 Gas discomfort "Too much food" Ground pressure to eat more "Lots of gas" in other crewmembers Eating prompted bad discomfort and gas
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	palatability and preference
Description:	preferred rehydratable food to wet packs
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	food quantity consumption
Description:	"I'm convinced when you get in flight and your heart powers down and you do less work, you just eat less. And you go in a power-down state; three meals a day in a 16 hour day approaches absurdity," Consumed wet packs like gangbusters. Some wet packs need to be hot, they would have been much more palatable.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	corn chowder
Description:	"It triggered a Captain's Mast and restricted crewmember to quarters for the rest of the mission, except the lunar surface, and eliminated corn chowder from everybody's diet right there."
Comments:	"everything triggered"
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	distaste for instant breakfast and the coke
Description:	"just totally developed a distaste for that chocolate taste." "It hit my belly, and it was just like an explosion."
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	gas
Description:	Took Mylicon prior to EVA for gas symptoms
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Food/Nutrition
Issue:	Gas and loose stool
Description:	"an awful lot of gas passed in flight" averaged a bowel movement every other day "Two crewmembers on the way home got very loose" stool CDR never did. Evans: "Yes, it wasn't loose, it was a catastrophe. "Would you believe bubbly?" "Foaming" No pain, but uncontrolled "Normal zero-G stool was "far from being firm," required pushing it down into the bag with a napkin. 2nd crewmember had same stool problem the following day, after an EVA.
Comments:	Dr. Hawkins prescribed two Lomotil that night and two the next morning.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Launch/Re-entry Issues
Issue:	Leak Rate in the capsule
Description:	Leak rate ½ upper limit of 0.2
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What is the range? Is this a concern?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Launch/Re-entry Issues
Issue:	Re-entry Observations
Description:	a) Development of Drogue chute was impressive but not intolerable b) Sea sickness was a problem on re-entry secondary to being upside down for approximately 15 minutes. Meclizine was little help for nausea c) Cabin was very hot and uncomfortable in the suits on re-entry (See Questions) d) No ventilation in the cabin on re-entry.
Comments:	Crew will require cooling in suit/cabin for greater than 30 minute stays before recovery
Resolved:	No
If Resolved how, when, where?	
Questions:	What could have been done differently to make re-entry more comfortable and less distressing?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Launch/Re-entry
Issue:	Re-Entry Observations
Description:	a) Seats were adequate despite the force of re-entry throughout the body -no injuries were reported -impact was taken by the fiat of the back b) Sensation of spaceflight pitching up during re-entry as g's increased
Comments:	Max g's were approximately 6.8 -7.0
Resolved:	No
If Resolved how, when, where?	
Questions:	Duration of 6.8 -7.0 g force?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Launch/Landing Suit
Issue:	"Fast drop surge tank pressure"
Description:	"Fast drop in surge tank pressure. Possible tunnel pressurization leak? Over pressurization suit and it relieved?
Comments:	
Resolved:	
If Resolved - how, when, where?	
Questions:	Is this common? Could over pressurization cause increased difficulty?
Summit Topic:	No

Source:	BME logs
Topic:	Launch/Landing Suit
Issue:	long time preparing for Interface Verification Test
Description:	"takes to long to prepare for IVT"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How much more time do we need to schedule?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
Issue:	lack of temp control
Description:	Suit inlet temp has ranged from 50-75 during prelaunch prep-"undesirable"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What are we doing to better control temperature in the launch suit?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Launch/Landing Suit
Issue:	Suit Problems
Description:	a) Fastening helmet is difficult, Why? b) Suits were bad, helmets were bad, gloves were bad, underwear was bad! (No details given) c) Need to be able to administer medications/aside from just H2O in the suit. d) H2O in suite -cyclic accumulation problem-blue hoses had H2O condensate. e) Recommend to leave helmet/neck ring disconnected in re-entry so CM can clear their ears, If CM unable to run hand into helmet, they may enter without bubble helmet. This would require padding under neck against the headrest for support and protection.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	1. Why was fastening helmet difficult? 2. What made the Suits were bad, helmets were bad, gloves were bad, underwear was bad 3. What Mode do you need to administer in the shuttle? Engineer can we do this?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
Issue:	water feed transducer
Description:	Water feed transducer acting up
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Explain how the transducer was acting up?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
Issue:	warm hands in suit
Description:	Hands are noted to be warm in suit but rest of body is comfortable
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Why? How much of aerobism? would this be during exploration missions? How could we fix it?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Launch/Landing Suit
Issue:	Design Observations
Description:	a) Taking the suit off/putting it on triggered SMS secondary to head/neck flexion required to get into suit. Ames would go in first, approximately 20 seconds later the head could pop through. During this time, CMP had definite symptoms of tumbling forward.
Comments:	
Resolved:	
If Resolved how, when. where?	
Questions:	Was this avoidable, either by suit position changes or delaying suite donning/doffing?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Launch/Landing Suit
Issue:	temperature
Description:	Crewmember reported they were cool and requested suit exchanger bypass
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What was cool? Were you yourselves cool in the suit? Explain temperature variations in suit?
Summit Topic:	Yes

Source:	BME logs
Topic:	Launch/Landing Suit
Issue:	Suit inlet temperature
Description:	Suit inlet temp has been high 30-40 is now 75.5 cabin s=temp is 79, which is wall temp, therefore, cabin temp must be 80-90
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What are the expected ranges of all places on the suit where temperatures are recorded? How was the suit's overall temp and does it need to be improved?
Summit Topic:	Yes

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Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Launch/Landing Suit
Issue:	Design Observations
Description:	UCD took considerable time to use while in suit.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Is it possible to design a urine collection device in cabin that can be used while crew is in suit without having to zipper down? i.e., long hose connected to overboard dumps that could connect to suit device
Summit Topic:	Yes

Source:	BME logs
Topic:	Launch/Landing Suit
Issue:	water found in suit
Description:	Water found in CDR suit on landing
Comments:	why the question?
Resolved:	
if Resolved how, when, where?	
Questions:	Was there water found in the CDR's suit? Did we find what caused this?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Launch/Landing Suit
Issue:	H2O in suit loop
Description:	H2O in suit loop yesterday in LM. Crew reports CO2 secondary then H2O secondary to that after 5 min
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How is the sensor linked to the H2O?
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
Issue:	water in suit?
Description:	PCQ2 3.5 sensor malfunctioning, ECS thinks water in loop. We hope it is not water in CDR's suit?
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Why do you think water would be in his suit? What are the possible ramifications of this? Was there water in his suit?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
issue:	Temp
Description:	CSM cabin temp 58 suit inlet temp 39.5 glycol temp control failed to regulate
Comments:	this seems horribly cold didn't this adversely affect the crew
Resolved:	
If Resolved how, when, where?	
Questions:	How did these temperatures affect the mission? It seems as if there were wild temperature changes do you think this affected how you felt?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Lunar Dust
Issue:	dust problems
Description:	CDR: "We were quite dirty, lot of dust on suits, particularly up the legs to the knees, and the gloves and arms. "Pretty much black like we'd been working in powdered graphite…" Seemed to be clinging to us." Banged feet against the strut and a lot of dust fell off our feet. Concerned that once back in orbit they would not be able to remove helmet because of floating dust in zero g LMP: slept on floor, "wiped up the floor with your suit Crew brought back the outer suit liner and the EVA gloves. When gloves were removed after EVA, hands became contaminated with dust. also got dust particles in the eyes, but it was not difficult to clear the eyes. Wiped down with tissue or towels. Took several days to get fingernail bed clean. Before returning to the CM, stripped down and wiped off with a wet towel.
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Launch/Re-entry Issues

Issue: visor fogging

Description: CMP: bad visor fogging while in the raft. Used wave water to wash off the fogging

Comments:

Resolved: No

If Resolved how, when, where?

Questions:

Summit Topic: Yes

Source: Medical Mission Debriefs

Topic: Launch/Re-entry Issues

Issue: Landing Observations

Description:
a) Crew complained of fogging of vision while waiting on BIG raft post landing. They were unable to clear it from the outside
-Crew was concerned about safety in transfer from raft to cage
b) Almost a quart of sea water entered into each leg from the BIG
c) Crew would like to do away with the BIG
d) Benzedrine taken for MS upon landing
-no MS experience on landing

Comments:

Resolved:

If Resolved How, when, where?

Questions: Did the crew suffer any post-landing illnesses?

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Launch/Landing Suit
Issue:	Suit Observations
Description:	a) Crew did not experience tumbling sensation getting into or out of the suit as other crews had b) Commander reported his hands "got wet and red as blood" during lunar EVA c) Crew was able to bend down to knees and get up without problem
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Were the Commander's hands getting wet and red as blood a suit fit issue? Did this cause a problem? Or LMP?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Lunar Dust
Issue:	Lunar Dust Observations
Description:	Crew reports that they were quite dirty with dust upon return to LM 1. Suits were covered with dust to the knees and gloves 2. Dust seemed to settle on floor in LM even upon return to microgravity 3. Crew did not need to don their helmets in microgravity 4. Very fine grained material 5. Dust covered the gloves and was rubbed off onto their hands. They were not wearing glove liners 6. Crew would wipe off with tissue, then wet a towel and wipe off following removing the LPG 7. Dust was not noticeable in CM following the LM docked
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Should crews wear glove liners to prevent getting dust on their hands? Is there plans for containing dust? i.e., carpeting? Should crew some how wash off before returning in LM?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Lunar Dust
Issue:	lunar dust
Description:	dust on everything
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	BME logs
Topic:	Launch/Landing Suit
Issue:	H2O in suit
Description:	water in both boots would like to warm up air in suit
General Comments:	
Resolved:	Yes
If Resolved how, when, where?	
Questions:	How cold was the air? How much water was in the boots? Was it sweat or condensation?
Summit Topic:	Yes

Source:	BME logs
Topic:	Launch/Landing Suit
Issue:	H2O in suit
Description:	H2O in suit may just be cold air causing sensation of liquid against the skin.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How cold air accounts for H2O in the suit? How cold was the air. Was it a problem?
Summit Topic:	Yes

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Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
Issue:	suit temp
Description:	Suit Temp
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What was the expected and allowable suit temperatures?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
Issue:	pressure change
Description:	Suit change in pressure sensor failure
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What caused this?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
issue:	water in suit
Description:	lots of water in his boots and shirt hoses
Comments:	this continues to be a problem and a concern this was also a problem in Apollo11
Resolved:	
If Resolved how, when, where?	
Questions:	how did the design changes that took place after Apollo 11 not fix the problem that was there on apollo 11.
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
Issue:	water in suit
Description:	"where is all the water coming from in my suit loop. I think it's cold air. The air is extremely cold with moisture In it, Making helmet fog.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What happened to the suit to cause this malfunction? How did this affect the mission?
Summit Topic:	Yes

Source:	BME logs
Topic:	Launch/Landing Suit
Issue:	HR
Description:	HR to 160 during suit integrity check problem
Comments:	Could this have been a bad connection?
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
Issue:	stale air
Description:	air is getting stale in this suit
Comments:	
Resolved:	Unknown
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
Issue:	leaking
Description:	suit leaking
Comments:	no more info on this if it was beyond what was expected
Resolved:	
If Resolved how, when, where?	
Questions:	Did the suit routinely leak more than expected
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Launch/Re-entry Issues
Issue:	heaviness feeling and 'footing'
Description:	CDR: for about 30 seconds after landing, after un-strapping and on the LEB, felt heavy the first couple of steps. Did 10-12 deep knee bends and “was right back home again.” Never felt heaviness again. Never felt light-headed LMP: had fewer tasks during re-entry g and was very aware of g-forces. Also felt heaviness after splashdown, which evolved very rapidly. While exiting the helicopter on the ship, "didn't have the sureness of footing that I would like to have. Never felt light-headed. Footing was sure within an hour: Stumbled once on way to the Medical quarantine facility. Never had mobility problems like the Russians had after their 8 days.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Launch/Landing
Issue:	chute didn't deploy
Description:	one chute didn't deploy hit water hard
Comments:	
Resolved:	Unknown
if Resolved how, when, where?	
Questions:	will there be enough other countermeasures to absorb one system failing?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
Issue:	pressure leak
Description:	found 0.3 psi leak over 1 min rechecked to be .1psi leak
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What is the source of the leak?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
Issue:	suit pressure check
Description:	Suit pressure check at the same time CM cabin pressure increased from 4.8 to 5.0 and suit pressure of 8.0 psi
Comments:	EC5 Working on it (what is EC5)
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Launch/Landing
Issue:	Suit condensation
Description:	Condensation reported in suit
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was this a problem even though it has been around for several of the Apollo missions?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Launch/Re-entry Issues
Issue:	adaptation to 1 g
Description:	CMP: 5 minutes to adjust to 1 g CDR: 5-10 minutes adjust to 1 g. No vestibular feeling at all, On the helicopter, everyone put their flying suit on and were stable enough to stand on one leg while doing it. Did notice the ship motion which took several hours to adapt to.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Launch/Re-entry Issues
Issue:	faintness while on ship after re-entry
Description:	felt "little more faint than I should have been" "once in a while I would be a little bit late on making a motion with my foot that would be a balance motion, normal balance motion like just stepping up on a step sideways or something" Sense of balance reaction not as rapid as it was, lasted until Christmas day.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	Sleeping bags no good
Description:	Sleeping bags no good prefer couch, secondary to inability to bring both knees to chest to relieve back pain.
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	What was wrong with the sleeping bags and how was the couch better?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	Cold symptoms treatment
Description:	Crew asked about using Rx if symptoms of sinus drainage and ear pain. FS concerned about lack of fever to diagnose a sinus infection
Comments:	
Resolved:	Advised crew to continue nasal decongestants. No antibiotics without fever
If solved how, when, where?	
Questions:	Will our medical approach differ for exploration missions from what we see now?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Flight Surgeon/Crew Interaction
Issue:	Crew Observations
Description:	a) Crewmember felt surgeon was not concerned about in-flight Illness (cold) b) Limit discussion of problems to individuals who are intimately familiar with the problem and the solution (problem with lack of PMC) c) "Communications were bad because too many people got into the act (Hot Biomed harness) d) Crewmember encouraged FS to act as more of an advocate of the crew than "as an experiment"-with regards to the flight plan demands on the crew. (see General comments) e) Crew concerned FS was withholding antibiotics for sinus infection.
Comments:	Apparently, the crew was asked to do an unscheduled TV show-Crewmember saw that two other crewmembers refused to do it. Surgeon needs to be sensitive to that.
Resolved:	
If Resolved how, when, where?	
Questions:	What was the PMC schedule for this mission? *Notes scribbled on the side of FS Log possibly at 97:23 as PMC with crew health status reported.
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Flight Surgeon/Crew Interaction
Issue:	Crew Observations
Description:	a) Logging H2O use is a waste of time. Just remind the crew periodically that space flight can dehydrate you and drink H2O frequently b) Logging food usage is a waste of time. The crew ate when they wanted, what they wanted and were too busy to log everything c) Crew photos -naked -were objectionable.
Comments:	
Resolved:	No
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	BME logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	Slosh or vibrations
Description:	"Can really feel slosh peak rate @40% then little closure just before end”
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Is this an expected difficulty?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	comment on docking ship
Description:	"that wasn't a docking that was an eye test?"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What made it an eye test and how could we fix this?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Launch/Landing Suit
Issue:	time allowed
Description:	Not enough time for suiting up
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How much time was given and how much was needed?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	CSM with LM jettison
Description:	"a lot of pitch, yaw and roll in CSM with LM Jettison”
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was this a usual occurrence?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Flight Surgeon/Crew Interaction
Issue:	Communication Observations
Description:	a) A PMC needs to be instituted on Apollo. Crew felt discussion about personal hygiene/illnesses were better on PMC. CDR felt very strongly that PMC should be available.
Comments:	LMP: "If I thought I had to tell the whole world about my BM's, I wouldn't say a word".
Resolved:	
If Resolved how, when, where?	
Questions:	Some CM's wanted AM and PM PMC's. Is this necessary?
Summit Topic:	Yes

Source:	BME logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	fuel cell
Description:	"working fuel cell problem"
Comments:	No further explanation of this event was mentioned
Resolved:	
If Resolved how, when, where?	
Questions:	what was this event? How or was it addressed? In light of Apollo 13, would this be a design flaw that was overlooked?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	quad A propellants
Description:	"Quad A propellants getting to Red line will roll ship 180 degrees to cool off
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What causes this?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	fuel cell #2 problems
Description:	Fuel cell #2 problems condenser exhaust cycling every on again every 10th cycle triggers waster alarm. Changes in 8-10 degrees in temp
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	What were these problems and does this pose a problem?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	LIO2 canister change
Description:	Crew advised of PCO2 of 3.0 mmHg, Canister change was not done?
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was the LIO2 canister change a hassle that kept you distracted from other more valuable parts of the mission?
Summit Topic:	Yes

Source:	BME logs
Topic:	Flight Surgeon/Crew Interaction
issue:	lightning
Description:	Thinks they were hit by lightning after take off
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Are there abort procedures well within lightning stroke range?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	interior lights
Description:	interior lights not being turned off by the hatch closure circuit
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Was this problem addressed?
Summit Topic:	No

Source:	Medical Mission Debriefs
Topic:	Flight Surgeon/Crew Interaction
Issue:	Medical Privacy Observations
Description:	Crew objects strongly to the fact that they have no private medical conferencing with F/S -Any medication used for any condition is broadcast to the MCC/public -Because of this, the normal “doctor-patient relationship” SOLUTION: Dr. Berry will have a PMC between the crew –F/S in the AM and PM
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	BME logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	summary
Description:	loss of power accompanied by bang resulted in loss of O2 in CM. Crew transferred to LM. No biomed since transfer.
Comments:	Power in CM forced crew into LM which had one port available for Biomed.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	waste dump
Description:	waste water dump has ice crystals look like a snowstorm
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Did this cause navigation problems? If not why was it noted were the ice crystals concerning?
Summit Topic:	Yes

Source:	BME logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	VCTA
Description:	reports blockage of VCTA but feels that he has reserve space EVA
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Can you have better explanation of this situation?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	tired
Description:	Flight controllers say crew is tired-but sound good to flight surgeon-Flight controllers are tired, however
Comments:	It seems paramount that flight controllers are well rested.
Resolved:	
If Resolved how, when, where?	
Questions:	What was the crew's recollection of FC duty requirements and how would fatigue effect their performance?
Summit Topic:	Yes

Source:	BME logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	FS denied request by FD
Description:	FS denied request to ask crew PRD's by FD saying "no" radiation report today"
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	gloves
Description:	gloves okay but will be glad to get rid of overgloves
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	what was wrong with the overgloves?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	FS commentary
Description:	FS commentary -what about a procedure card to help with doing a clinical ECG or what might approximate a clinical ECG w/o augmented leads with our sternal harness?
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	shorten mission by 1 day
Description:	management decision to shorten mission by one day
Comments:	why?
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon togs
Topic:	Flight Surgeon/Crew Interaction
Issue:	amount of citrus
Description:	Mission commentary "CM’s unhappy about amount of oranges and citrus they are eating and how it gave them the Farts!"
Comments:	Crews were required to take more potassium in diet to mitigate cardiac dysrhythmia.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon legs
Topic:	Flight Surgeon/Crew Interaction
Issue:	urine dump
Description:	crew reports all urine collected in a bag and then dumped and it was difficult to know when the dump was complete Capcom said forget it but crewmember said neither cap or crew is running this program but he is and he wants start and stop times, 1st bag 7 sec 2nd bag 28 sec 3rd bag 16 sec big big bag 1 min and 35 sec
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	was the crew not using the urine dump each time they went to the bathroom? if so was it that bad? What was wrong with it?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	IMU
Description:	IMU failure
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How did the IMU fail? Was this common?
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	no landing
Description:	No Circ. No landing this Rev b/c of CSM problem “operable locks? Operation drive motor is no go?
Comments:	cant really read hand writing? Kind of confused
Resolved: If Resolved how, when, where?	
Questions:	Could you explain what caused this problem?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Flight Surgeon/Crew Interaction
Issue:	Inadequate preflight
Description:	Crew felt they were shut out from participation in preflight communication and planning of the interface of medical data collection requirements and their procedures, such as urine collection, fecal collection and sensor management.
Comments:	Dr, Berry retorted, “Well, XXXX, there were some tiny problems and we won't -I won't try to horse foot around here to see who did what to whom in that area." CMP: “I think you missed the point of what they were bitching about."
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Medical Mission Debriefs

Topic: Training

Issue: Simulation

Description: a) The pogo and centrifuge were good training activities to simulate LEVA. as far as ambulation goes
b) Training simulated the LEVA activities pretty closely.

Comments:

Resolved:

If Resolved how, when, where?

Questions: Will pogo simulators be used to train for mission?

Summit Topic: Yes

Source: Flight Surgeon logs

Topic: Training

Issue: docking problems

Description: 4th attempt to capture with probe unsuccessful

Comments:

Resolved:

If Resolved how, when, where?

Questions: Was the probe a hindrance in all Apollo missions during docking?

Summit Topic: Yes

Source: Flight Surgeon logs

Topic: Training

Issue: Docking

Description: 4 unsuccessful docking try with probe try to dock with probe retracted "hard dock finally accomplished"

Comments:

Resolved:

If Resolved how, when, where?

Questions: Was docking with probe better than without?

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Training
issue:	EVA work vs sim training for EVA
Description:	LMP: An order of magnitude easier than our 1G training. Never really felt tired. Stayed well-hydrated. Managed the plan! CDR: easier to get around on the lunar surface, travel faster and easier. Did not feel uncomfortable at all during EVA-1. During EVA-2 was aware of workload effect on respiration rate. Did not feel 'overheated.' Noted a little sweating, probably limited by the Liquid Cooling Garment (LCG)--used medium flow in LCG when he felt sweaty or flush. Took short rests only on the steepest slopes of the crater, then proceeded "Never really felt like I was behind the power curve as far as the total workload was concerned." CDR noted their 2-day workload was, in his opinion, "about as heavy a workload as anybody ought to do.
Comments:	Dr. Berry noted heart rates over 150 at times for the CDR and LMP during EVAs. Heart rates slowed with rest during the EVA. LMP affirmed that if consumables were increased they could increase and extend their EVAs.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Training
Issue:	Education of crew on Med requirements and rationale
Description:	CDR: Medical training has been left to the last seven weeks prior to launch. Crew has not understood the rationale or specifics of requirements such as why the need for repeated 24-hour urine collection and multiple blood draws, Suggested early in the training syllabus medical time should be allotted to define the medical requirements, their rationale and their goal, including the theoretical underpinning, the mechanics and the protocol. At this time in the program, “medical requirement” still have not been formalized in any document.
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	Flight Surgeon/Crew Interaction
Issue:	Skylab drink bag
Description:	"Skylab drink bag helpful because you can use it on all other drink bags
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Is this drink bag still used? Why was it helpful?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Training
Issue:	Centrifuge
Description:	There is little correlation between centrifuge runs and what's experienced in flight. "Centrifuge is the biggest waste of time for crew training experience you ever saw, especially Pilots."
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	How much time is spent in centrifuge runs and should or could this be decreased and the time used more productively?
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	Training
Issue:	Fatigue
Description:	a) The crew was very fatigued (mentally) prior to launch secondary to very busy training schedule. Work day days typically began at 07600 and would end with debrief at 2200-0000 each night. Approximately three weeks before launch.
Comments:	a) Solution: Train/work late for a fixed launch date or flexible launch date once the work is done. Other options is to skip non-essential meetings Crew Recommendation: Crew recommended that the crew should use the 1st couple of months before launch for simulation training only; including sleep/rest, exercise and eating. That's it. Get all the technical briefings, systems briefings, and physicals done at L-60 or L-90. Also having simulations as your only planned event 60 day's before a mission would leave room for unplanned events i.e., some days will require 10-12 hours for sims, other days only 3-4 hours
Resolved:	
If Resolved how, when, where?	
Questions:	What is "single air test training"?
Summit Topic:	Yes

Source:	Medical Mission Debriefs
Topic:	Training
Issue:	Training Observations
Description:	a) Work crew in simulator only 6 weeks before launch.
Comments:	Remove all but the most important safety briefings. Ensure that the crew can have as relaxed a schedule before their launch.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	Yes

Appendix A
Apollo Summit Non-Attributable Report

Source: Crew Logs

Topic: General Questions (does not fit into any specific category)

Issue: Overall Mission Recommendations

Description:

1. Need more antibiotics and decongestants in kit
2. Need sleeping pills (short acting)
3. Need Donnatol for GI upset
4. Need private logs for crew
5. Need TM Diagnosis List
6. Need control of S/W
7. Need nose drops in kit -(Afrin?)
8. Need extra leads in repair kit for ECG
9. Need replacement thermometer (1 in kit broke)

Comments:

Resolved:

If Resolved how, when, where?

Questions:

Summit Topic: No

Source: BME logs

Topic: General Questions (does not fit into any Specific category)

Issue: fogging/ice on window

Description: hatch window and window 1 and 5 unusable secondary to fogging

Comments:

Resolved:

If Resolved how, when, where?

Questions: What counter measures are prepared to keep windows usable and without fog or ice?

Summit Topic: Yes

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	General Questions (does not fit into any specific category)
Issue:	window heaters
Description:	window heaters turned off because too hot
Comments:	
Resolved:	
It Resolved how, when, where?	
Questions:	Do we need automatic turn off and turn on for window heaters? Could this be a safety hazard? How did you determine those window were too hot?
Summit Topic:	Yes

Source:	Flight Surgeon logs
Topic:	General Questions (does
issue:	S-IC vibrations
Description:	Comments about S-IC vibrations
Comments:	Crews concerned over vigorous shaking during stage S-11 phase
Resolved:	
If Resolved how, when, where?	
Questions:	Is this a normal occurrence?
Summit Topic:	No

Source:	BME logs
Topic:	General Questions (does not fit into any specific category)
Issue:	CDR LMP prelaunch health
Description:	CDR took ornade for slight injection of nasal mucosa LMP took ornade for slight injection of right TM
Comments:	there are some differences between this and FS logs report
Resolved:	Crew had minor nasal congestion prior to launch. Required oral decongestants.
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	General Questions (does not fit into any specific category)
Issue:	pictures
Description:	pictures help but not like seeing it
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	Is there any new data that would help prepare along with pictures and topographic maps?
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	General Questions (does not fit into any specific category)
Issue:	Docking probe
Description:	Docking Probe is hot
Comments:	
Resolved:	
if Resolved how, when, where?	
Questions:	What caused the docking probe to be hot? How hot was Hot? Was this common on all the flights?
Summit Topic:	Yes

Source:	BME logs
Topic:	General Questions (does not fit into any specific category)
Issue:	explosion
Description:	loss of power and bang venting noted all crew HR went 60 to 125-130
Comments:	
Resolved:	Yes
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	General Questions
Issue:	switch failure
Description:	launch system review complete early cut off in SII stage secondary to low combustion sensors to be activated and shut down
Comments:	
Resolved:	N/A
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	General Questions (does not fit into any specific)
Issue:	engine burn
Description:	burn complete "not too much push accelerometer shows nothing”
Comments:	
Resolved:	N/A
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	General Questions (does not fit into any specific category)
Issue:	CSM power
Description:	CSM completely powered down, we will not know CO2 level in CM, splash down at 73 or 82 hrs, no problem with O2 plenty although CO2 limited
Comments:	
Resolved:	Unknown
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Flight Surgeon logs
Topic:	General Questions does not fit into any specific category)
Issue:	CSM O2
Description:	CSM 3.54 Ibs O2 =10 hrs 3 Ibs =8 hrs LM 63 Ibs rate of .6 Ibs/hour LM CO2 reserve with existing LIOH canister 57 hrs at average rate
Comments:	
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Source:	Flight Surgeon logs
Topic:	General Questions (does not fit into any specific category)
Issue:	"probe investigations"
Description:	Discussions of “probe investigation” utilizing TV, may wait till after they sleep
Comments:	Probe investigation-will remove probe drouge and inspect-TV record with live TV it time lines to MCC
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

Appendix A
Apollo Summit Non-Attributable Report

Source:	Medical Mission Debriefs
Topic:	General Questions (does not fit into any specific category)
Issue:	transcript errors
Description:	There are a number of transcript errors in the initial 10 pages: should be 'salt-depleting' rather than soft-depleting' asymptotic should be 'acidotic' positive nitrogen should be 'positive hydrogen'
Comments:	Extended discussion of how to use medical findings of return to preflight levels to end NY Times adverse stories and congressional negative reaction to manned flights. A rather rambling discourse.
Resolved:	
If Resolved how, when, where?	
Questions:	
Summit Topic:	No

APPENDIX B
NON-ATTRIBUTABLE PANEL DISCUSSION & POST-PANEL RESPONSES

7-9 June, 2006

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EVA Suit

Crew Medical and Safety Issues

EVA Suit Crew Medical & Safety Issues

Ambulation and Center of Gravity (CG)

1. **What do you recall about the CG of suit during walking vs. during stationary working? Would it have been better if the CG was low and forward vs. high and aft?**

   It probably would be better if CG was a little lower, but the human body will adapt regardless. Reducing the size and weight of the backpack would help solve the problem. Backpack and suit on Apollo weighed 194 pounds.

   Reduce the mass of the suit by a factor of two, general mobility by a factor of four.

   Glove needs to be like a human hand.

   Don't make moving the CG your primary priority. Move the CG only if it becomes convenient to do so while taking care of other issues like reducing the mass of the suit, etc. Human beings are very adaptable and we were certainly comfortable by the third excursion.

   You automatically leaned forward when you were standing and you learned how to run at a fairly significant velocity with dynamic stability.

   Post-Summit Questionnaire Responses

   Soldiers for thousands of years put the weight on their backs.

2. **Debriefs imply loping was the most biomechanically efficient form of movement. Was this in part from suit restrictions, or was it the most natural movement in 1/6 g? Was the workload perceived as higher with walking slowly vs. quicker loping or hopping?**

   It was a natural response to take the easier way to move which was by loping or skipping. Always try to set up a dynamic motion.

   The metabolic cost was less with skipping than with walking. It took more time and was more difficult to walk. It was very comfortable in the 1/6 g environment. Crewmembers adapted quickly and were comfortable within 5-10 minutes and got better with each excursion. It didn't interfere with the efficiency of operations, even in the early part of an excursion. There were many factors that cut efficiency, but that was not a major one.

   Ambulation tended to be somewhat variable with each individual and whether they ultimately selected the most efficient way to do it will be determined in the tests that are being conducted.

A cross-country ski technique was used by one crewmember that had quite a bit of cross-country skiing experience, but the films showed that others tended to develop the same method.

Some liked hopping or skipping instead.

There is an ongoing quantitative analysis looking at speed and efficiency using biomedical and photographic data from Apollo and this is a good effort. There are a number of sequences that can be used from the television data so crews can be advised on what might be the most energy-efficient way to move. With the equipment available now one can decide what will work best. You can give them good advice on that.

Post-Summit Questionnaire Responses

No responses

a. **Obviously you preferred to hop and we're seeing in the testing that you're metabolically more efficient going at faster speeds. If you're trying to do detailed observations and so forth where you don't want to go fast, did you feel compromised in the suit? In other words, the suit is set up to go fast and it's optimized metabolically for that. Did you feel compromised when you were trying to work at a station or area to bend over and pick things up, etc?**

Due to the design of the suit, you didn't normally bend over. That's why there was a need for tools with long handles. If you really wanted to get down close to something, you'd just go down as a push-up or lean against a rock.

Bending the knee was in the suit.

Some crewmembers mentioned that it was fatiguing to go uphill, which is probably because they were trying to bend their knees. We need a better knee joint.

Post-Summit Questionnaire Responses

CMP: his EVA was from the orbiting CSM. Neither weight nor mobility was a problem.

b. **Did you feel that the hip mobility was adequate?**

As you can see from the video footage, we were running, and the motion was primarily at the hip. It was easy and ankle mobility was good as well. The problem was primarily with the knee.

Post-Summit Questionnaire Responses

No Responses

3. **Did any muscles feel more fatigued than you would have expected, during ambulation, for the degree of exertion? If so, which muscle groups?**

   Hills seemed steeper and tougher to climb on the lunar surface and loping couldn't be used. It was fatiguing to walk uphill.

   General fatigue was experienced, with thigh muscles specifically affected.

   Post-Summit Questionnaire Responses

   No responses

4. **Was there any particular muscular strain noted when trying to slow down, or stop, from a quick lope?**

   No, however the stop needed to be anticipated.

   Post-Summit Questionnaire Responses

   No responses

5. **Did you feel the suit was too heavy**, **too light, or about right?**

   It was substantially too heavy.

   A lightweight suit would be easier to operate and much more comfortable.

   Assembling the suit was a complicated process, partly due to the small area allocated in the module. If a larger area was available, it may have been easier.

   Post-Summit Questionnaire Responses

   No responses

   a. **What about the mass issue when it comes to your movement and your ability to negotiate turns and things of that nature?**

You adapt to the fact that you have a lot of inertia relative to normal walking or hiking on Earth, because the mass certainly hasn't changed and you have to be conscious of that.

Your total weight is only about sixty pounds, even though you're carrying around 370 pounds of mass. You adapt to that, but on the other hand it is one of the reasons why you work harder than you would like to on the moon. It takes energy to climb a slope or something like that. You'd like to use that energy for more productive tasks.

Post-Summit Questionnaire Responses

No responses

b. What would you recommend as a target mass reduction?

My target for mass reduction has always been a factor of 1/2, but anybody can come up with a number.

There are some advantages to having some mass, particularly if you don't fix the flexibility of the knees. You can use that mass to help you bend the knees, but I assume that there will l be a much more mobile leg than we had during Apollo.

Thinking in terms of Mars, I hope we will build a new heritage for suits. There are other suit issues, since the 3/8 gravity is a significant increase over 1/6.

Post-Summit Questionnaire Responses

No responses

c. Do you think you could have a suit that was too light? Picture yourself working on the moon with an ultra light suit. It strikes me that somewhere between microgravity and 1/6 g you're going to want some restraint to do work.

Hypothetically you could have too little mass, but again you would adapt to that. If you need to push against something, you just lean more. You depend on the adaptability of the human beings to take advantage of whatever situation they are in and 1/6 g is an environment you can take advantage of.

It's something you can test, if it doesn't cost too much. Assume there would be an energy savings by reducing the mass. This would be a distinct advantage over anything else that might be a problem.

Reducing the mass of the suit is probably not an important goal, as much as improving the glove.

Post-Summit Questionnaire Responses

No responses

6. What were the characteristics of the suit walking up or down slopes? Any muscular strain noted?

Ambulating down slopes was difficult because it was hard to arch the back in the 4.26 psi pressure suit.

Hopping or parallel skiing was actually used to ambulate down slopes. It was necessary to be more cautious going downhill. If you lost control, you could possibly roll down the hill.

No muscle strain occurred while hopping or parallel skiing.

Post-Summit Questionnaire Responses

3.75 psi pressure suit (not 4.26)

7. What were the characteristics of the suit climbing up and down the ladder? Any muscular strain noted?

The ladder did not cause a problem, although glove improvements would have decreaded the concern of falling. It might be helpful to have a line attached to you so you wouldn't fall off. On the ladder, the suit issue was getting through the hatch.

Post Summit Questionnaire Responses

No responses

8. Based on experience with the LM ladder, would a taller ladder be a significant concern for falls and loss of balance? If so, how to mitigate.

Better glove performance is probably the most important, although we really didn't have any problems going up and down the ladder. We actually didn't use the steps, but would just grab the rails and slide down and you tend to pull yourself up with your hands more than with your feet. That was partly because of the low mobility in the knee.

If it is a weight trade-off of any significance, don't worry about the rails. The sides of the ladder provide all the gripping surface that you need.

We learned a lot about how to get equipment and ourselves in and out of the lunar module. At first, we used a clothesline or pulley system to get equipment out. We quickly abandoned that and just started dropping it to the person that was already on the ground.

You start doing things in a much more efficient manner once you learn that height is not an issue in 1/6 g. You just shove the equipment out the hatch and the other crewmember takes care of it.

Some equipment was hung with a strap on the side of the module.

The rung width and height on LEM were good.

Post-Summit Questionnaire Responses

No responses

9. Did the body postures required to navigate the LM hatch for ingress/egress cause undue muscular strain?

There was no strain on the back or other muscles and no residual soreness in any muscles. The back had to be arched and the heart rate went up.

The design of the hatch was the problem. Crewmembers had difficulty maneuvering through and one of the primary reasons was that the DSKY of the primary navigation and guidance was directly above the hatch. That is one thing you would hit and you didn't want to hit it very hard.

The suit was the max limit with the backpack. You had to arch your back to fit in and crewmembers had to help each other get through. The highest heart rate occurred while getting in and out of the hatch.

You need a hatch that is sized appropriately for an inflated 1/6 g pressure suit. If changes are made in terms of mass mobility, it will be a non-issue in the future.

If an airlock is used in the next lunar lander design, it may make ingress and egress easier and will also be a good idea from a dust control standpoint.

Post-Summit Questionnaire Responses

This hatch thing was obviously easier in 0g.

10. Debriefs implied resting in the suit while standing was comfortable. For future EVA ops, would some form of resting seated bench, or tripod support offer any advantage during rest periods (aside from sitting in a rover seat)?

The suit was self-supporting. You can rest your arms on the suit.

There was no feeling of the need or opportunity to rest. Psychologically we didn't want to use the time because we were already behind.

A suggestion was made for suits to be custom-made for each individual crewmember. Need to have custom sized utility suits available as well.

Post-Summit Questionnaire Responses

No responses

11. Did you experience any 'vertigo' during entry into a 1/6 g field, and with activities on the lunar surface?

Minimal or no symptoms occurred.

However, the crews' remarked in the debriefs that they were "wobbly" upon initial contact with the lunar surface. This was short-lived and did not result in any compromise in their gait or ability to perform activities.

Post-Summit Questionnaire Responses

No responses

12. What aspects of the suit were specifically troubling in performing routine tasks with regard to workload and injury?

See information above regarding glove issues, suit mass, lack of flexibility in the knee joints.

Post-Summit Questionnaire Responses

The primary issues were glove tactility, suit mobility, contingency capabilities and crew controls.

- The great amount of energy needed to move around
- First attributed to the fact that mis-fitting suit joints were not co-located with the subject's joints
- Every motion required compressing the suit volume, a potentially fatiguing activity, this didn't turn out to be as bad as we'd thought but it took a long time to figure out what were our real issues.
- Our test program did not identify any knee joint problems -two reasons. 1) testing was done standing up, climbing stairs and walking. 2) given the weight of the EMU, having a semi-rigid knee joint actually made life easier for us.

Vision

1. Was the field of view out of the helmet adequate to see displays (in terms of near/far vision factors)? Was the view adequate to avoid trip hazards and maintain footing?

Was the horizon reference in your peripheral vision adequate, with the side shades down, to ensure good vision and balance?

Everything was visible, however would have liked more peripheral vision. It was less efficient to have to turn your body rather than just turn your head. Peripheral vision should be improved. It did not interfere with functionality, just needed to turn your body.

It was difficult to know what the other crewmember was doing and you would have to turn from your task to view crewmember.

Visibility was also limited because you couldn't bend over easily and you had the camera in front of you. Hopefully we will have a far less bulky camera system that you can point and shoot. There was a tendency to work around those kinds of difficulties and we were able to do that, but they were still there.

Post-Summit Questionnaire Responses

More head movement would have been good

You don't have to be in lunar environment to know this

a. **You had mentioned that you couldn't see your feet and you adapted to that, but all things being equal would it be better if you could see your feet?**

It is always better to be able to see your feet, but when you're walking normally you usually are anticipating several steps ahead and you can do that on the moon, too.

Post-Summit Questionnaire Responses

Do you do this on Earth?

b. **In deep sea diving, there are helmets that have a neck ring and it has a liner that fits to your head so you can turn you head, rather than your whole body. Do you think that feature would be worth looking into on a lunar suit?**

Yes, look into that. It's always going to be more efficient to be able to turn your head.

Post-Summit Questionnaire Responses

Obvious

2. **Given possible new in-helmet Heads Up Display (HUD) technology, would such displays be valuable, or potentially distracting and contribute to slips/falls?**

The complexities and desired information of the HUD should be considered and should not be a distraction. The checklist would be a nice feature to have.

The HUD and other fancy things are nice, but I question whether the complexity and reliability over long-term flight is really going to help or hinder. You have to have back-up systems that are somewhat manual. We had back-up systems right down the line. The more complicated you get with how you get information to the suited crewmember, the more risk you run of losing that system, so be careful.

Dr. Jones responded: We talked about simplicity and that's a really good point, but at the same time we're trying to diminish the overhead that the crew had and if you have to strain to look down at a cuff checklist, it's taking your time. If we could do it in a way that's pretty easy for you, we'd like to do that as long as it's reliable and tested.

Determine the benefit, cost, and reliability of the system. If it turns out that it's not reliable or when you start to work with it you find it can be done just as well with a cuff checklist as with a HUD, then change your approach.

A reliable HUD displaying consumable information or feedback when depleting key resources or medical information could be useful

Post-Summit Questionnaire Responses

Reliability is a big factor.
As the fighter pilot

a. **You mentioned that it would be nice to have the ability to call up displays, not that you wanted them constantly running with a lot of confusing information, but using an auditory cue call up information you wanted to see. Would this be helpful?**

Yes, the HUD primarily should be presenting the operational information that you need at the instant. If you want to see oxygen, you say "oxygen" and it appears.

Post-Summit Questionnaire Responses

Cost

Suit/Boots

1. **What tasks were the most fatiguing to perform in the suit? What tasks required the most dexterity?**

   Tasks related to the hands were the most fatiguing.

   Tasks requiring finger dexterity, such as holding anything tight (i.e., hammers, drills, changing camera settings), were especially difficult and fatiguing.

   More flexibility in the glove is necessary.

   Post-Summit Questionnaire Responses

   Better gloves needed. Head mobility would reduce body motion.

2. **Within the limits of the suit, did the posture used for kneeling activities cause back/leg strain? What level of knee padding would be advised for protection?**

   Kneeling used extra energy. If the suit was more flexible, kneeling would be used more often.

   Kneeling allows you to be closer to whatever is being worked on; however, it could exacerbate the dust problem.

   Post-Summit Questionnaire Responses

   No responses

3. **Were there any pinch points, pressure points, or areas of abrasion in the suit?**

   A lot of abrasion and scraping occurred in the hands and gloves and at times caused blood under the nails and pulled them off at the quick.

   This occurred only on the lunar surface, not training.

   The skin on the back of the knuckles was abraded in some crewmembers, never in training, only on the moon

   This could have been incapacitating for future EVAs if had been doing repeated ones.

   Fix the Gloves! -possibly due to lack of use of comfort glove and hands being soaked with sweat in the glove.

Post-Summit Questionnaire Responses

No. On a 40 minute EVA from the CSM

4. **Did the boots provide adequate traction and tactile feedback to your feet for maintaining good ambulation control?**

There were no problems with the boots. There was no concern about ankle sprains or injuries with falls. You may find places on the moon where you're going to be walking over bare rock, although that isn't very likely. In that case, you'll find the little spheres of glass in the regolith will cause it to be slippery and the boots don't deal with that very well. If you get off the ladder and put your foot directly on the side of a boulder, it was slick, but this will very rarely be a problem.

Post-Summit Questionnaire Responses

No responses

a. **With respect to the boot**, **did you feel like you were getting enough information to have a stable gait? The boots were hard on the bottom**, **with galoshes over them.**

They were very comfortable. It never seemed that the boot was causing any difficulty.

The lunar regolith is a very efficient transmitter of acoustical energy and you can actually feel somebody hammering on a core probe through your boots, if you are close enough. The energy is focused and it goes through the soil very efficiently.

Post-Summit Questionnaire Responses

No responses

b. **In regards to the coefficient of friction on the surface, did you feel slippery on the regolith?**

It was never slippery on the regolith. It has a very high bearing strength. It has been tamped by micrometeorites over a very long period of time.

The upper layer is a little looser with less bearing strength, so that gives you a grip.

Also, every particle is like a tiny piece of Velcro. It hooks with every other particle, so the coefficient of friction is pretty high within the regolith material itself.

Post-Summit Questionnaire Responses

No responses

5. Was ankle support adequate to avoid ankle injuries with unequal footing?

There were no issues. Always observant as to where you were placing your foot so as not to have any injuries.

Lighter weight suit may have more vulnerability. The suit gave a sense of support and protection.

Post-Summit Questionnaire Responses

No responses

6. Were there any pressure points with boot inserts or with the lunar boot instep strap? Was arch support adequate? Would proper arch support designs be advised for frequent EVA activities?

No discomfort with the boot.

Post-Summit Questionnaire Responses

No responses

7. Did the lunar boots provide adequate thermal comfort?

Yes.

Post-Summit Questionnaire Responses

No responses

8. What lunar surface EVA activities (e.g., egress down the ladder, ingress, use of tools, rover ops, etc) do you feel pose the greatest risk for injury?

The Lunar Rover pilot was at greatest risk. He would be the first one to get hit when driving on the side of a hill.

The commander on the high end was concerned about falling over.

Post-Summit Questionnaire Responses

No responses

9. **What features in future suits would be most beneficial to reduce workload, and reduce the potential for injury and falls?**

As discussed above,
Gloves
knee flexibility,
mass.

Put pads in the knees for kneeling on the regolith.
Also use a self-sealing pressure garment, to take care of a small puncture.
Post-Summit Questionnaire Responses

Test Operations
- During testing - subjects were never matched to the suits – difficult to sort out if problems were due to design or mis-fitting suits
- Before unloading the suit with artificial load relief, take a look at the impact they have on test operations. The use of load relief was so obnoxious that when it came time to do our final thermal-vacuum tests, I elected to work unencumbered by load relief. I thought the potential for getting tangled up in pulleys, cables, etc. that I could not see or reach, was a greater hazard than the risk of losing suit pressure and having the whole thing fall on me.

a. **Discuss soft suits versus hard suits and the trade off.**

From the Apollo crew point-of-view, there is a tendency to favor the soft suits, but we didn't have much experience with the hard suits.

Everybody should be objective enough to look at it. The next set of explorers will need to determine what they like best and weigh the advantages against the disadvantages.

Post-Summit Questionnaire Responses

No responses

Hands/Gloves

1. **Did certain activities on the moon cause finger/hand pain vs. fatigue?**

The most fatiguing part of the tasks was repetitive gripping which caused fatigue in the musculature of the forearm.

The crewmembers were unable to specify cause of problem.

There were issues with not only fingernails being pulled back (onycholysis), but also a situation of skin being abraded from the top of the knuckles.

Post-Summit Questionnaire Responses

No responses

2. Were hand/finger issues on the moon different than any issues encountered during ground training runs?

We saw no trauma in training, though muscle fatigue occurred. Training sessions weren't as long as the lunar sessions, though.

The very long terrestrial sessions developed the same kind of problem, so it's either a duration problem or in some cases it may be related to the dimensions of your hand, which needs to be looked at.

Energy, time, and money should be spent to take a serious look at how to improve the glove. Although there have been improvements for Shuttle and Station, the gloves probably aren't as far along as they need to be for exploration activities on the moon or Mars.

Another part of the problem is pressure of the glove. The lower the pressure, the less strength it takes to manipulate.

If you decide to move back towards a single gas low pressure oxygen system, you need to realize there are complications in doing that system because of things that have happened since Apollo.

We tried to list all the operational advantages to having a low pressure single gas system and that is well worth a very hard second look.

Post-Summit Questionnaire Responses

No responses

3. **Any specific glove touch-temperature issues when handling materials? (ladders, tools, rock specimens, controls)?**

No, although thermal input from the sun was felt at one point.

Post-Summit Questionnaire Responses

With improved insulation, don't forget that once the insulation heats up, it's really hard to remove the thermal content. One of our final tests was to demonstrate I could pick up a two hundred something degree rock and hold it for 15 seconds or so. Using a metal bar heated to the desired temp, I was able to grasp and hold for l 0 seconds or so until the inside of the glove became very hot. Fortunately, since the suit didn't fit, I was able to pull my hand entirely out of the glove.

4. **Did any dust get into the inside of the suit between EVAs in the LM? Was there any cumulative skin irritation on the hands or elsewhere from dust exposure between EVAs? Did this affect a subsequent EVA? Did the EVA aggravate any irritation?**

No problems, except dust accumulated in the neck rings.

Post-Summit Questionnaire Responses

and wrist rings on A-16.

5. **What, if any, feature of the space suit gloves would be most beneficial to improve with regard to hand injuries?**

The hands were not used in any significant way. Efficiency was probably no more than about ten percent of the use of the hand.

Step back with a clean sheet design of the glove with the goal of getting as close to normal dexterity and use of the hands as possible.

Crewmembers had difficulty with repetitive grasping because it caused fatigue in the forearm muscles. The longer you're out there, the more problems you have.

And, almost everybody on the moon had problems with fingernails.

Spend some money and time working the glove issues, adding dexterity, lowering the pressure in the suit, if possible, as well as trying to diminish fatigue from gripping tasks and to diminish trauma to the hands.

Make easy to don and doff; give room in the airlock if you have room to get the suit on easily, if you are going to do frequent EVAs.

Recommendations for the glove:

- Consider the inherent design of the gloves.
- Possibly a robotic hand could be used or a mechanically-augmented, power-assist glove for repetitive tasks.
- Modify fit and size. Properly fit the gloves to the crewmembers after they are designed and assigned to them. One crewmember had his gloves cinched up so tight that he lost all of his fingernails when he got back. It wasn't due to the glove, but because he had them fitted so tight.

Post-Summit Questionnaire Responses

Look at a wrist seal and depressurized glove. Perhaps even for temporary use on challenging tasks.

- Gloves were the most obvious challenge - required a significant level of thermal protection.
- Multilayer insulation worked on the back, but the palm and interior required a thermal barrier that could withstand abrasion and compression.
- The real issue was simply the need to compress the palm side insulation.
- Perhaps contemporary materials will allow developing a thin, flexible mesh with high conductivity that could be used to interface with an active heat rejection system for future explorers.

a. Unanticipated changes occurred in 1/6 g environment that contributed to the problems with the gloves on the moon's surface. Could you elaborate on that?

It may be related to the length of time in the glove, since the fingernail problems did not occur during training.

Once fitted for the gloves, the crewmembers were left on their own to figure out how best to use them and that was appropriate, but with experience the crews could be advised of what may work and may not and test various things.

Even wearing silk liners and cutting nails as short as possible, the fingernail problems were not prevented.
The fingernails still scraped against the bladder. With a bare hand in the glove (without silk liners), severe chafing was experienced by at least one crewmember.

There are many nuances that are probably worth exploring, even with a new designed glove.

Post-Summit Questionnaire Responses

No responses

Physiology/Performance/Hydration/UCD/DCS/Thermal

1. Would you like to know your own heart rate, metabolic rate, or other physiological information during an EVA?

We could feel what was happening with our bodies and responded accordingly.

Intermittent feedback was received from CAPCOM regarding suit information/consumables and it was acceptable.

A heads-up display would be acceptable, esp. with verbal request for heart rate, esp. on Mars when don't have mission control watching over you.

It may have helped one of the lunar EVA crewmembers to have heart-rate information as he was going too fast and injured himself during a coring activity.

Post-Summit Questionnaire Responses

Would have helped on Gemini IX and XI.
Potassium depletion was a problem. Some way of monitoring condition would be good.

GT-XI - Heart rate is not a reliable indication of work load. Perhaps the most important physiological parameter is hydration.

2. Describe your food and water intake prior to the EVA terms of amount and timing?

We always had breakfast before going out.

We ate fairly well on the moon, but it would have been nice to have more water available, if only in the event of a contingency. Some crewmembers may have been conservative with the available water, but that was wrong. In desert survival, you learn that you should drink the water you need when you have it, rather than partialing it out.

There was a consensus among the crewmembers that having a larger water supply would have been helpful and useful.

You lose a lot of moisture, even with the LCG.

It would be important to have some food available, something that could provide a good lunch.

The fruit bar mounted inside the suit was sometimes problematic because you couldn't always get to it.

A liquid drink with energy nutrients might be an option, as long as it doesn't contain caffeine.

Once suited up, we sometimes went 10 hours without a break. Adrenalin was a factor and we had a lot to do. If it is convenient to get to, having a solid or liquid carbohydrate would be helpful.

Don't overcomplicate things. Keep it as simple as you possibly can because human beings can adapt to these kinds of situations very easily.

Post-Summit Questionnaire Responses

It would be a good thing if there were a simple, non-invasive, way to evaluate hydration in real time. It's been my experience that you have to force yourself to drink often, especially in the suit, because it's generally a nuisance task.

3. **How thirsty did you become during an EVA? By the end of an EVA?**

   See #2 above.

   Post-Summit Questionnaire Responses

   No responses

4. **Did you feel the amount of water in the bag was sufficient**

   It would have been nice to have more

   Post-Summit Questionnaire Responses

   No responses

5. **Given adequate compatibility with the suit, do you feel other liquids such as Gatorade or juices should be a crew option for the drink bag? (In light of the Apollo 16 orange juice leak in preparing for EVA #2)**

   High energy drink with nutrition would be good, but it's nice also to have some plain water.

   Post-Summit Questionnaire Responses

   AW: Need to keep chemical balance in body.

6. **Debriefs show a number of crewmembers found the food stick valuable? Any comments on satisfying hunger, providing energy**, **ease of access?**

   The fruit bar mounted inside the suit was sometimes problematic because you couldn't always get to it, but it's nice to have something solid to eat.

Post-Summit Questionnaire Responses

No responses

7. **Please comment on the efficiency of the Urine Collection Device (UCD) during EVA? Was there irritation from the device which was exacerbated by movement in the suit?**

   What we had was adequate, but you should continue to consider better ways to do it.

   The condom catheter was undersized.

   If there is a better system that is not gender specific, then we should consider it very seriously and test it to see if it will work in 1/6g.

   The wicking diaper system does not work well in 1 g, but may possibly work well in weightlessness. If we can improve it significantly, then we should.

   Post-Summit Questionnaire Responses

   What does gender specific mean?
   The UCD was only used for EVA; operations - lunar surface, etc. The CM was equipped with a relief tube. Haise did wear his UCD on 13 and it resulted in a urinary infection. For EVA operations I don't see how you can improve the device.

8. **Do you have suggestions for urine collection with frequent EVAs and mixed gender crews?**

   See #7 above.

   Post-Summit Questionnaire Responses

   Have fun with this one.

9. **Apollo 10: Crew was very concerned about voiding difficulties during time-critical ops. Crew suggested creating a device made of aluminum to plug into the suit to facilitate voiding with the suit on. In particular, a UCD that can be used with the suit on without having to zipper-down. What was this device, and was it ever developed?**

   Were not aware that is was ever flight tested.

   Post-Summit Questionnaire Responses

Apollo 10 was not normal!!

10. Was the Liquid Cooling Garment (LCG) wet at the end of an EVA? If so, where was it wet and did it cause any skin irritation through the comfort garment?

The air cooling systems were not adequate for more than an hour, however, there was very good cooling from liquid cooling, even to the point of over-cooling if you let it run full up.

The liquid cooling garment was wet from sweat after each EVA and we let them air dry on our bodies.

Post-Summit Questionnaire Responses

No responses

11. Were you ever over-cooled by the LCG?

Yes, see #10 above.

Post-Summit Questionnaire Responses

No responses

12. Was the suit and helmet adequate in providing thermal protection? Were there any thermal cold or hot spots?

There were no hot spots, except on one occasion which was actually quite comfortable. When driving to the station, one crewmember stated his arm was in the sun for a significant period of time (30-40 minutes), heating tired arm muscles which felt quite therapeutic.

Post-Summit Questionnaire Responses

Suit was OK, helmet cooling from O2 flow was OK.

13. How strong was the concern regarding Decompression Sickness (DCS), or did you feel that it had been eliminated through design?

One crewmember questioned if there was only one case, if it wasn't another issue and whether it was misdiagnosed. However, in questioning the affected

crewmember, he absolutely felt it was DCS. He feels he is a "3-sigma" individual in his sensitivity to DCS. He bases his belief on an experience in an altitude chamber where he had pain in his left knee which spontaneously resolved upon repress. During his Gemini X mission he experienced pain in the same knee that was similar but more severe than what he experienced during the altitude chamber exposure. It started with capsule depress and went away over a period of several hours. Again in Apollo 11 on capsule depress he had a similar pain (location and character). It resolved spontaneously over several hours and was not severe enough to interfere with activities. He denies other episodes of knee pain during altitude exposure. He denies significant injury to this knee though he admits to numerous minimal sports injuries during his lifetime.

Crewmembers started prebreathe right away, as soon as the helmets were on.

Crewmembers suggested not only having low pressure in the suit, but also low pressure in the habitat. There would be many engineering and operational issues to consider.

You're going to have to bite the bullet and continue to use the PVS system and try to work at the lowest pressure possible to get the prebreath, to something that is inconsequential and somehow monitor the potential developing maximum levels. Take a hard look at whether you can gradually migrate back to PVS.

Post-Summit Questionnaire Responses

No responses

14. What were the contingency plans for any DCS symptoms?

We talked about this with the docs, and in general we did not worry about it because of the

100% oxygen environment of the LEM.

Post-Summit Questionnaire Responses

No responses

15. Any retrospective symptoms of DCS that may not be previously accounted for by suit fit pain or musculoskeletal strain?

In my aircraft, I quit prebreathing for well over an hour and I had some decompression as well. If you're going to launch with some nitrogen in your cabin, maybe you just have to extend the prebreathe.

Post-Summit Questionnaire Responses

No

16. **Do you feel the pre-flight EVA exercise training program adequately prepared you for EVA, from an exercise capacity standpoint? How much more hand/arm exercise training would you have incorporated into your routine?**

Yes in general it was adequate, however one area to improve both pre-flight and maybe on the way out is conditioning the forearms, esp. gripping.

Post-Summit Questionnaire Responses

Not on Gemini, but was in good shape for Apollo. Restraint systems in orbit a must.

17. **Would you prefer one long EVA session, or two shorter sessions on a given day should the "work-efficiency" index be favorable? Ratio of: time of EVA/time of pre/post EVA activity) A break between EVAs would allow rest, hydration, food, replanning, etc. in the LSAM.**

One long session would be the preferable way of operating, even if you're there longer than we were. Crewmembers preferred to keep going as long as the system would allow.

It's time-consuming to break the EVA up with a repress in the habitat, and then depress to go out again, including performing many checks.

Post-Summit Questionnaire Responses

Obvious

18. **How many daily EVAs in a row, for a given set of crewmembers, would you feel be possible without undue physical stress or fatigue? (taking into consideration level of ambulation, task difficulty, etc)**

Could do three days in a row but better to do every other day or two days in a row then off for one.

Post-Summit Questionnaire Responses

No responses

a. **You mentioned that you had alternate EVA days. If there were 4 crewmembers available to go out, would it make more sense to have all 4 out on a given day and then a day off? Or 2 out one day and 2 out the next day, so that you are doing continuous EVAs?**

Although you should be flexible to be able to do one or the other depending on the objectives, the preference would be to alternate 2 and 2. That would enable mission control from the cabin during Mars expeditions. If you get used to doing this on the moon, it will be easier on

Mars. Crewmembers could alternate every other day, then allow one day off each week for whatever they want to do.

Keep in mind that a 6-month mission is very different than a 3-day mission. An actual plan for a 45-day Mars surface stay has been developed and copies are available. It should be left up to the real-time operational planning team, but if everything is going nominally throughout the mission, then alternating EVAs and teams will be an efficient way to operate.

Post-Summit Questionnaire Responses

No responses

b. **So, there should not be an attempt to plan EVAs day after day, but leave it up to real-time planning and some autonomy of decision-making should be left to the crew?**

Plan the operations on the surface so that you protect the crew from themselves. The crews will work too hard to try to get everything done and they'll risk becoming dehydrated and having serious physiological problems. Work out a schedule with the crews ahead of time, but excessive workloads on consecutive days is going to hurt somebody so leave some autonomy to the crews.

With extended ops on the moon, you should try to establish all the experiments in the first week or so, and then allow the crew to just have a day to do R&R on the surface, just for the sake of being on the moon and recharging their batteries, so to speak. The schedule could be one day on and one day off, or two days on and one day off, but guard against crewmembers overworking themselves. If you go too long on a field exploration, you could be taking more risk than necessary.

You have to be careful with pre-launch activities, as well, to make sure problems don't exist when crewmembers launch.

Post-Summit Questionnaire Responses

No responses

19. What other suit changes would you advise to reduce workload, or mitigate injuries/strains, for the next generation suit not already discussed above?

Lighter, better gloves, more mobile.

Post-Summit Questionnaire Responses

Gloves, knees & in general better mobility

Our goal was to make the suit operation as autonomous as possible and providing confidence in its contingency capabilities. If we're going to send folks out, we need to provide a modicum of protection against life threatening events, no matter how improbable.

- Rather than carry large quantities of O2 it would be worth exploring the ability to create a self sealing layer on the inside of the suit to stem the loss of pressure. It doesn't have to be a perfect barrier, just enough to minimize the leakage due to minor punctures, leaks, cracks, etc.
- The most debilitating event can be one that allows the helmet to fog. It may be worth while to develop a way to periodically spray pure O2 on the front of the helmet, which can also reduce the local CO2 concentration during periods of exertion.
- The cooling system should also be self sealing with regard to leaks.
- Retain ability to make/break gas connection in a vacuum and provide contingency O2 on rovers, etc.
- Always use the buddy system when conducting an EVA.

a. One of the things we are struggling with for exploration is whether we should have one suit that can be reconfigured for different phases of the mission or do we go with two suits? Do you have any thoughts with your experience?

It depends on how the suit design turns out and if you can get in and out of it quickly. One crewmember commented that there should be only one suit. All operations should be performed in one suit that is easy to operate and flexible.

Post-Summit Questionnaire Responses

One suit if possible.

Lunar Surface Ops

Lunar Surface Ops

Dust

1. **Describe any issues that arose due to lunar dust entry into the vehicle?**

   We dusted but there was still dust everywhere. It smelled like gunpowder, however you would get desensitized to it. Suits would have to be doffed before entering the vehicle.

   Post-Summit Questionnaire Responses

   Yes

2. **Approximately how much lunar dust lingered inside the vehicle?**

   Dust is cleared rapidly in the cabin by lithium hydroxide. Dust is very abrasive and there are jagged fragments. The dust on the surface was a problem because it covered all your gear, visors, etc.

   Post-Summit Questionnaire Responses

   The ECLSS intake system that intakes and redistributes the air.

   a. **A lot of the debriefs said that after they got back in microgravity that dust caused a lot of problems, so we are particularly looking at how the dust was cleared, symptoms, causes, etc. On some missions, the dust was like a cloud, but on others it was cleared fairly adequately by the lithium hydroxide ventilation system. We are curious why dust was a problem on some vehicles, but not on others. What were the differences in the ECLSS systems between the different vehicles, or is it a difference in volume, etc.?**

   The amount of dust that came back after landing should have been pretty consistent. Maybe some crewmembers cleaned more than others, or the ventilation system differed vehicle to vehicle.

   Post-Summit Questionnaire Responses

   Not so at all with the rover fender failure.

   A-16 lost a rover fender.
   So did Apollo 15.
   Apollo 17 lost one on the first EVA and it was repaired.

How about different landing locations with different characteristics. Vehicles were alike!

3. **Crews reported that they were quite dirty with lunar dust upon return to the LM. Dust was difficult to remove from any surface, particularly the hands and fingers. This contributed to getting dust in the eyes. Glove liners were not used on Al1-13 mission, but were worn on subsequent missions. What type of material in the glove liner would best prevent the type of contamination you described? What other measures could be taken to protect the crew from dust contamination prior to doffing the suit?**

   Lunar dust was embedded between skin and nail beds on all fingers. It was from handling

   rocks inside the lunar module. No glove liners on early missions, hard to get dust from under

   fingernails in those cases.

   It took six weeks to grow out. the lunar dust from the nails.

   Beta cloth, fractured silica, and silk were mentioned as possible better materials for glove liners.

   There are many reasons why you don't want lunar dust in your equipment or anywhere else. Consider it from an engineering context, rather than the impact on humans. Take the angle of prevention.

   Post-Summit Questionnaire Responses

   No responses

4. **Did the inhaled lunar dust particles result in any specific symptoms (allergic reactions, sneezing, tearing, nasal irritation, coughing, sore throat, congestion, or other symptoms)?**

   The dust smelled of gunpowder.

   Helmets were not removed until the particles settled and went away.

   There was dust in the mucous membranes of one crewmember that caused stuffiness and a changed voice, but it didn't seem like dust produced an inherent problem.

   The dust clears once it is in the environmental control systems.

   No medications were used for symptoms, but today Claritin could be taken.

   We had bigger problems with fiberglass irritation.

   Studies are being conducted on silicosis and this is important work.

Post-Summit Questionnaire Responses

What is this fiberglass problem? Law suit pending.

5. **If you experienced inhalation irritation from exposure to lunar dust particles, how long did these effects last? If you put on a mask to reduce the irritation, how long did it take for symptoms to disappear? Did the irritation cause any decrement in your ability to perform tasks?**

   Sinus problems went away after the third EVA, so it wasn't a major issue.

   This was contradicted in the following statement: During sampling for the microbiology program, exposure to lunar dust from the suits caused a reaction that worsened with each of the 3 sampling periods. The first exposure caused a stuffy nose and watery eyes. Lab results showed about 5% eosinophilias and a couple basophilia. On the second exposure, there were more symptoms of watery eyes and stuffy nose. Eosinophilias went up to 9% and there were some basophiles. On the third exposure, it was impossible to stay inside the spacecraft long enough to get the sample due to extremely watery eyes. In order to get the sample, it was necessary to get out, take a deep breath, then return to get the sample. Again, there was a 9% eosinophilia and 5% basophilia. Others performed the same function after the return of other missions and had no reaction.

   Dr. Jones stated that it was interesting that it didn't passivate during the transport. There will
   obviously be individual variation in the response and we may have to do susceptibility testing
   before flight.

   Post-Summit Questionnaire Responses

   What the hell!!

6. **What skin effects were caused by lunar dust? Specifically, was there any redness of skin, itching or any other specific symptoms that you can recall?**

   None.

   Post-Summit Questionnaire Responses

   Yes

7. **What eye irritation did you experience? Specifically, was there any redness of eyes, itching or any other specific symptoms that you can recall?**

Not any significant, did get some in eyes, but more of a nuisance. Put suits back on in one flight to prevent breathing the dust. One CDR wouldn't let dusty suits into CM until bagged, due to dust.

Post-Summit Questionnaire Responses

Yes. Why do CDR get the credit -when CMP did it! A-12

8. **Were dermal and ocular effects lasting? If so, for how long; and did this cause any decrement in ability to perform tasks?**

No. As far as prolonged exposure to lunar dust, experimentation on Earth will not resemble the in situ properties of lunar dust, so we have to be careful about the conclusions we draw. We need to work from an engineering point of view to develop a layer of defense. Engineering actually worked pretty well on Apollo, whether advertently or inadvertently. The bearings on the lunar rover showed no symptoms on any of the missions.

Although it doesn't seem to have had an effect on the crewmembers, we had very limited exposure. Chronic exposure is very different than short-term exposure.

The lithium hydroxide filters seemed to pick up the dust fairly quickly. If you think it's important, the lithium hydroxide canisters in the CSMs could be analyzed to see how much actually got in the cabin. The sub-micron sized particles may be most worrisome physiologically for humans, but it is really unknown.

There needs to be a layer of defense to protect not only the crew, but also the equipment. The EVA suits may be used hundreds of times and dust will be a major factor in that. We saw dust scratches on our neck and wrist rings. It is extraordinarily penetrating dust.

There were differences in the landing sites relative to the nature of the dust, but it is unknown whether there are significant differences from a physiological standpoint.

Post-Summit Questionnaire Responses

No responses

Surface Tasks

1. **Apollo 12: The CDR/LMP stated the shadow pattern over the terrain/crater edges gave the illusion that the slope was much steeper than it actually was.**

   Reflective light in the shadows isn't as evident as on earth. Craters did appear steeper visually. We knew we had to go down into that crater, so it gave us concern.

   There is a general visual phenomenon, there isn't good reference for your eyes and the estimation of distance is off. All sorts of ambiguities on the moon (i.e., slopes, terrains, sun shadows, bland environment). No environmental references like on the Earth (i.e., trees, houses, poles).

   A comment was made regarding the length of a crewmembers shadow because it always

   looked shorter and it was needed as a reference. The shadow was calculated prior to the

   EVAs and could be used as a baseline. After a period of time adjustment does occur.

   Post-Summit Questionnaire Responses

   No responses

   a. **What is the steepest incline you tried to navigate?**

   The steepest incline encountered was a 20-26 degree slope. If it was steeper, we would not have made an attempt.

   The degree you could operate at safely depends on the task. It is easier to decide to go up a hill, because it is more difficult cooling down.

   There was concern for falling down slopes. Also if went down a steep slope, you couldn't be sure that you could get back up.

   Post-Summit Questionnaire Responses

   No responses

   b. **If there was a lighter suit, would you feel safer or be able to go up a higher slope?**

   It was coming down that was a situation to be more cautious.

   Post-Summit Questionnaire Responses

   No responses

2. **How did the crew negotiate descending down the craters with this illusion, did it really cause a problem or was it an interesting observation?**

   See #1 above.

   Post-Summit Questionnaire Responses

   No Responses

3. **If it was a potential problem navigating the lunar surface, what would be the recommendation for eliminating this problem for future crews?**

   Can always follow your tracks back to the habitat. INS possibly.

   Post-Summit Questionnaire Responses

   No Responses

4. **During the lunar EVA, the crews often worked harder during "rest" periods (as evidenced by heart rate data) than during work periods. However, the crew did not feel this level of physical activity pushed them to their exercise capacity limits**.

   Many crews worked as hard or harder during rest periods because that was our time to catch up. The EVAs always had more scheduled than you could do in the time allotted.

   Didn't have time to rest. Recommend doing EVA for 2 days then rest the third, so don't make fatigue mistakes.

   EVA is not as safe if you are mentally fatigued.

   Post-Summit Questionnaire Responses

   Yes. Unless looking for an intervelometer.

   Heart rate is not a reliable indication of work load.

5. **Although the crews did not report feeling physically challenged during the lunar EVA'S, can you offer any insights on how you might have felt carrying out this surface activity timeline over the course of 7-14-30 days?**

   The most important issue is to get enough rest. If you fall behind in your sleep, there is potential trouble.

   It is difficult to sleep, you doze and the adrenalin is pumping too much to sleep heavily.

Several crewmembers worked a 30-hour day. As long as the crew is given time of their own, that is the main issue, and they can use it as deemed necessary whether it is sleep or not. Sleep is an individual thing.

Privacy is needed for sleep. Crewmembers get comfortable when adapted.

Circadian rhythm was not important on the moon.

Mental and physical rest plans should be introduced. Should have planned breaks and rotations, maybe alternating flight crews and plans.

Post-Summit Questionnaire Responses

RG: Yes

6. How do you feel the pre-flight EVA training program prepared you for lunar EVA?

The POGO and centrifuge training were beneficial. There is no special training needed for 1/6 g EVAs.

Adaptation occurs quickly regardless, You learned your limitations.

You did as much as you could to get in shape. ALSEP training in 1-g was excellent. 0-g training was more important than 1/6 g. Only need a 1/6-g fam session.

Post-Summit Questionnaire Responses

No Responses

7. What would you do differently in your training for these longer surface sorties?

There may be more tasks you need to train for. Task-specific training for specialized operations is optimal.

Mission focus should be project-oriented and not timelined. The crew needs to have more freedom. Leave time for unexpected activities.

Post-Summit Questionnaire Responses

No Responses

8. What does the crew consider were risky tasks during LEVA?

Puncturing the suit was considered the biggest risk. Even though it was puncture safe, it was still a concern in a new environment. If a suit actually got penetrated, look into something that causes a self-seal. Self-seals are used in the military.

The only other concern was if your zipper was not working, broken, leaking, etc.

Another concern was hand fatigue. Some experiments could have been deployed robotically.

Post-Summit Questionnaire Responses

Yes

a. What activities had the highest risk of falls/injuries?

Going down slopes, esp. if carrying heavy objects, possibly driving rover on sloped terrain.

Post-Summit Questionnaire Responses

No Responses

b. Discuss any particular muscoskeletal strains...back, abdomen, legs...related to falls or slips.

Note: Apollo 12: Visual spatial distortions/disorientation due to certain sun angles on sloping terrain

Apollo 15: Drilling for core samples and establishing a port for heat flow experiment at the end of EVA #3

Apollo 15: CDR deciding not to wear seat belt on rover to save transit time back to LM at the end of EVA #2

In the video, it was obviously taking energy and this all starts from the pre-mission decision that at this particular station, one crewmember was to do some individual sampling while the other crewmember performed some necessary housekeeping at the Rover.

Because my hands were tired and because I didn't have a good sense of how much pressure was putting on the bag, I dropped the bag. So, I was in the process of trying to first of all recover the samples that fell out of the bag and a number of things. This was just a whole set of bad decisions in pre-flight planning, as well as in operations, and I hope that with that kind of experience we will never do that again.

Post-Summit Questionnaire Responses

No Responses

c. **Along the same token, you said that none of these falls really caused any significant strain, impact, injury?**

No, the main consequence was that you got dirtier than you should have.

Over time, you could see the dust migrate up the suit.

In terms of hazard, you're falling as if you're only 1/6 your height, so you don't hit very hard and you're in an extremely strong suit.

Post-Summit Questionnaire Responses

No Responses

d. **So, when you fell, did it hurt at all**

No, due to the rugged suit we were in, if had a lighter or more flexible suit then maybe.

Post-Summit Questionnaire Responses

No Responses

e. **One of the things that we need to be careful of as we do this testing on the ground with the POGO system, our center of mass is moving at 160, but we're in the suit under 1 g, so our impression of a fall under those conditions is probably different in reality?**

Yes, and you have to take into account the workloads. You're still moving in a 1 g field, so you're doing 1 g work with your arms and legs.

Tests are being conducted in the KC-135 with a 1/6 parabola to obtain quantitative net rate versus speed.

Post-Summit Questionnaire Responses

Yes. But be careful -you always start from a stable position

9. **Does single-man parallel ops over 2-man teamed ops for deploying experiments and equipment reduce the risk for falls or other potential injuries?**

   Never felt physically at risk. The configuration for deploying the experiments is not a factor.

   Post-Summit Questionnaire Responses

   No Responses

   a. **Is it safer to operate tools independently or with another person?**

   Do not send one person out alone unless it's an emergency or mandatory.

   Post-Summit Questionnaire Responses

   No Responses

10. **From a crew performance standpoint, with consecutive daily lunar surface EVAs being considered, is there a better time during the crew day to schedule these events?**

    The EVAs should be based on the sun availability. It gets hotter at high noon due to the sun. OK to do EVA in Earthshine periods, light is adequate.

    Post-Summit Questionnaire Responses

    How do they know?

11. **In terms of reducing crew physical workload would a robotic "companion" on EVAs have proved useful or more cumbersome? What about a low tech walking golf cart solution? Could robotics reduce your workload or reduce fatigue?**

    A robot should perform routine, systematic, repetitive, menial tasks. This will free the crewmember for other tasks.

    Post-Summit Questionnaire Responses

    No Responses

12. **What was the impact of lunar dust? How much was "tracked in" on the suits during lunar EVA and what impact did it have on vehicle systems and crew health?**

See dust issues above.

Post-Summit Questionnaire Responses

No Responses

13. **What part of the lunar surface EVA caused you to expend the most energy? Metabolic studies seem to point to the last 30 minutes of the EVA, where the crew was ingressing the vehicle. Do you believe this contributed to fatigue and was there a risk of injury?**

The hatch should be made where you can go straight in. Make so you don't have to arch your back and tilt the backpack in order to get back in. It's a volume configuration issue.

The risk is death if you can't get back in.

Post-Summit Questionnaire Responses

No Responses

14. **What was your optimal speed on the surface above a brisk walk?**

Half again as fast was average speed. Routinely measured at 6 kilometers an hour.

Can lope quicker on the moon than briskly walk on Earth. Up to 10 km for an hour.

Post-Summit Questionnaire Responses

No Responses

a. **You also mentioned that you would like to see suit recharge capability on the Rover?**

In future Rovers, you should have the ability to recharge your suit or at least live off of Rover consumables when you're driving or working around it. This will require a change in engineering, as well as a change in mission rule. It will be a design challenge, particularly in that dust environment.

And it wouldn't be just the Rover, there may be other activities, particularly when you get to a lunar base phase, where you're going to be doing things outside, but in a fairly fixed position near the base/habitat. You will have to live off of a different set of consumables.

It's one way to reduce the mass of the suit. It's also a way to extend the duration of your activities.

Another advantage is that if you decide that you're going to protect yourself against a solar particle event while you're some distance away from any pre-positioned shelter and you're going to use some method of excavating a trench to reduce the exposure envelope as well as possibly even live underneath the Rover for a few hours as additional protection, then you would like to have an extension of your consumable supply.

Post-Summit Questionnaire Responses

Yes. Not a bad idea.

b. We also discussed that you thought it would be acceptable to have a deployable shield for radiation protection on the Rover?

You should certainly do some conceptual designs and determine the consequences. There may be unintended consequences terms of CG, rollover, etc.

Post-Summit Questionnaire Responses

Roll the dice.

c. Comment on driving the lunar Rover in your suits. How comfortable was that? It often looked precarious when going up and down on the lunar surface.

It was very comfortable driving in the suits.

The wrist motion was very good. You'd just rest your hand on the controller and you could move it and guide the Rover very well. It was a very effective transportation system and was easy to use.

There is a problem with visibility on the moon because when you're driving down sun you have no shadow definitions and you have to adjust either your speed or move in a zigzag pattern to avoid a hazard.

The one thing we would have liked to have is some kind of an automatic position determination so that you could save time looking for where you were actually trying to go. We spent quite a bit of time trying to find the right crater patterns.

With a GPS system available, we would have saved some time.

Post-Summit Questionnaire Responses

No Responses

d. How long could you maintain your pace? What would you modify on the flight plan?

Work two days, then rest on the third day. When fatigued, you make mistakes and are not as safe as you think you are.

Take a day off after EVA and get your suits prepared for the next EVA.

Come up with a formula to give people mental as well as physical relief. You can maintain this effort for short periods of time, but not for extended timelines. There are good operational reasons for having people alternate EVAs. there are several things to be done on a day off, flight planning, etc, not necessarily a true day off.

Post-Summit Questionnaire Responses

- Perhaps the most important recommendation would be to stop trying to maximize every minute of surface time with pre-planned timelines, etc.
- The ISS folks seem to have learned this
- If you want to explore, let the probers pick their own pace and focus.
- The next set of missions should not be short sorties, but part of an ongoing program.

e. If the ladder from the habitat were higher, would you have concerns?

Would make the ladder wider, possibly with a rail.

Post-Summit Questionnaire Responses

No Responses

In-flight Illnesses

In-flight Illnesses

Space Motion Sickness and Entry 'Sickness' and Disorientation

1 **How strong were your symptoms and were they still present during transfer to the lunar surface?**

Symptoms were felt the first day, however it is individualistic. (One crewmember commented that in his experience approximately 1/3 to 1/2 of the crewmembers experienced symptoms.)

Space motion and space adaptation are two different things.

Crewmembers worked through the symptoms and felt that it did not impair their work performance.

Most of the symptoms are gone within a couple of days and crewmembers felt adapted to the new environment.
Preflight measures were not taken to prevent Space Adaptation Syndrome. (There was a recommendation to consider pressure points.)

Crewmembers took preflight measures by flying T-38s, but it is unclear whether this helped or not.

There were no reports of problems during Mercury or Gemini, but it may be that they just didn't mention it to the flight surgeons

Many countermeasure were considered. Flying was one method.

There was probably still some stomach awareness, however.

During Gemini, felt "punk" for 24 hours, that is "didn't feel like going dancing".

Early Apollo only felt punk 2-3 hours, but late Apollo it was gone after an hour.

Post-Summit Questionnaire Responses

Fluid shifts to head almost immediately upon arrival on orbit. Found that sinuses tended to stop frequently and sometimes for prolonged duration. Annoying only. During Shuttle, we noticed that five minutes on the treadmill would immediately clear the sinus.

a. **Can we do anything to use other countermeasures effectively?**

Since symptoms decrease with subsequent missions, it may be advisable to fly crewmembers with previous microgravity experience. However, there is some contradiction in the following crewmember comments:

- "On early flights I had a great time, but later on I got very sick."
- "Same for me...symptoms came later with training cycles. Not sure why."
- "It luckily didn't happen to me. It's individual. There must be a way, through history, to get a getter definition of this problem."
- “I’ve never experienced motion sickness in my life."

Post-Summit Questionnaire Responses

Yes. Find a way to predict.

2. Did you notice 'vertigo' or disequilibrium during LEM ops and post landing on the moon? Comment specifically on accomplishing tasks in the LM during entry and landing, and accomplishing tasks in the immediate post landing period on the moon. Comment specifically on accomplishing tasks in the LM during entry and landing on moon symptoms.

See response to questions 11, above, Ambulation and CG issue above

One crewmember stated that it is a function of the inner ear or it could be the emotional state.

"It may be a psychological thing."

Post-Summit Questionnaire Responses

Yes

3. How would you compare your 'stability' while walking in 1/6 g vs return to Earth and 1 g?

Easier to ambulate at 1/6 g, it is wonderful. We need a little time to get our sea legs when got back, otherwise no real issue.

Post-Summit Questionnaire Responses

No Responses

4. Some crew found transferring from CM to LM disorientating, and reported that it may have contributed to SMS. Are there any orientation cues or suggestions in the design of the two vehicles that may help minimize or ameliorate this disorientation? Given the current architecture for the CEV LSAM, how could your suggestions be implemented?

Post-Summit Questionnaire Responses

Don't worry about it.

Practice in the KC-135 or C-9 in zero g in the CM to LM simulators

Yes, slightly disorienting -but not the source of SMS. Just interesting. Perhaps have a training setup where transfer can be done, even unsuited. In Apollo we had no such device -on CM or LM, but not combined. Therefore it was mostly unfamiliarity with what's where.

We did not have a problem with this issue. I think the answer is "Believe Your Eyes" and don't move fast, especially your head. Training issue!

Find crews that orient by sight not by mental gymnastics.

Back Pain

1. **Crew described significant back pain during the first couple of days of the mission. To the best of your memory, can you describe the back pain in terms of location, character, intensity, exacerbating and alleviating position or exercise most effectively relieved the pain?**

   One crewmember commented that his back never felt better than it did in 0 g and he never used the fetal position as a therapeutic technique.

   The Exer-Genie was used for deconditioning. "It was also nice for the spirit and a good way to relax."

   Back pain may be related to elongation of the spine, but this is not yet clear.

   Back problems were not necessarily discussed with Flight Medicine because Apollo crewmembers thought it was due to sleeping problems.

   However Dr. Ross stated that several Apollo crewmembers did complain of low-grade, chronic back pain. The problems were non-disk related. Some crewmembers improved, however some did not. Massage and exercise helped alleviate the pain somewhat, as well as getting into a fetal position.

   Military history was also a consideration. Some crewmembers had problems from low back to cervical spine, including injuries. 90% are lumbar spine problems that seem to be related to piloting high-performance jet aircraft. It is important to discuss this with consultants that can provide the correct types of therapy.

   It could be that back pain is not "space normal" and we need to determine what we can do about it.

   Post-Summit Questionnaire Responses

I don't believe lower back pain is due to military/jet experience. I think it is related to offloading of lg upper body weight. Lower back definitely went into spasms. Fetal position felt good but may not be good therapy.

Yes.

2. **Considering the configuration and constraints of the CEV (e.g., 5.0 cu^3 volume) compared to the Apollo CM, how would you advise the crew/engineers to design the couches/exercise equipment, sleep compartments or restraints to help minimize back pain symptoms?**

Strengthen the abdominal muscles to prevent back pain. Doing lots of sit-ups seems to help. Develop preflight exercise protocols.
"Low back pain cannot be designed out, Take Motrin and go on."

The ASCR program can lessen the risk of injury. The ASCRs are very aware of these problems and are paying attention to this with preventive measures. Core strengthening pre-and in-flight helps. This will be used for long-duration flight. Creativity will be necessary for implementing the program in a constrained environment. The Exer-Genie was the only piece of hardware in Apollo. It had problems due to heat build-up in the rope during use.

The crewmembers considered it a threat if heat built up after too much use.

Examine the spacecraft to determine what can be worked with or against to get the proper exercise. Dr. Ross reported that a multi-disciplinary approach is being taken to work on training and preflight injuries/anomalies for prevention rather than cure. This includes engineers, astronauts, suit techs, ASCRs, etc.

Post-Summit Questionnaire Responses

The Exer-Genie did not work. Call me for a detailed explanation.

No. The Exer-Genie was misused. It is isometric not dynamic -no heat should be present.

3. **Did the CDR/LMP experience any low back pain on the lunar surface? Were there any positions or exercises that the crew performed that improved their symptoms? If so, what were they?**

Post-Summit Questionnaire Responses

Not me.

Eye Irritation

1. **Apollo 10: Conjunctival irritation occurred in the CM secondary to fiberglass in the cabin. Required the crew to use saline eye drops. Source of the fiberglass or circumstances not explained in the debrief. What was the source of the fiberglass in the cabin? Was the eye irrigation system adequate to clear the irritation?**

   Fiberglass irritation was mentioned above, however crewmembers did not elaborate.

   Post-Summit Questionnaire Responses

   Not on our flight

   Was there fiberglass present?

Joint Pain

1. **The Apollo 11 CMP described onset of left line pain after launch, similar to that experienced on Gemini X and in altitude chamber testing. The cabin atmosphere and oxygen concentration being considered for CEV/LSAM/ Lunar habitat will involve a gradual decompression, although the exact AP is still under debate. Although the CMP's symptoms were not attributed to dysbarism by the flight surgeons, it is certainly suggestive of this condition. Can the CMP describe in detail the symptoms and events surrounding his joint pain. What recommendations can the crew offer for the atmospheric parameters being considered to CEV/LSAM?**

   See EVA q. 13.

   Post-Summit Questionnaire Responses

   I have listened carefully & still believe my symptoms indicate nitrogen in left knee. No problem for me.

Sleep

1. **Did the coronal discharges interfere with sleep i.e., sleep onset, efficiency, etc? Was there a particular mission phase that the discharges were more noticeable?**

   Noticed flashes more when closed eyes, before went to sleep.

   Post-Summit Questionnaire Responses

   We did an experiment for flashes. Did not interfere with sleep.

Find a way to make taking sleeping pills not a sign of weakness in an astronaut's mind. A sleeping pill should be thought of as a chemical tool.

Yes. No effect at the time?

Musculoskeletal Injuries

1. **What injuries or aches and pains were most common following EVA? How could you reduce the likelihood of injury?**

   Soreness in the forearms was the most common, but usually was better by the next day.

   Post-Summit Questionnaire Responses

   No responses

2. **How did you 'rehab' or recover from injuries" What preflight preparation reduced these symptoms? Did any injuries interfere with task performance? What injuries and aches and pains were unexpected?**

   Post-Summit Questionnaire Responses

   Had wrist ring cut on right wrist to bone – used no fix until return.

   No injuries.

   None

3. **On the lunar surface, did you ever experience a fall that produced a 'hard' landing? Did equipment ever fall on you?**

   No. Falls on the lunar surface were "gentle."

   There was little concern for injury except falling onto a piece of equipment or breaking your visor.

   Post-Summit Questionnaire Responses

   No responses

4. **We hope to design out, as much as possible, risk of trauma and injury, so that we can reduce the potential need for acute medical care. For example, better suit design could reduce the likelihood of shoulder and hand injuries. Do you have any suggestions for how we might do this, and what hardware and tasks might be redesigned to reduce these risks?**

Post-Summit Questionnaire Responses

Fit the suit to the person -new gloves that incorporate mechanical closure for gripping without fatigue.

Better glove design -squeeze more tennis balls?

Suits much more critical for extended stay on surface.

Better suit design but also design exercises that strengthen muscle & joints effected

5. Did the design of spacesuits for lunar work allow you easy movement, or was it difficult to maneuver?. Did these difficulties contribute, in your opinion, to susceptibility to falls while working on the lunar surface?

A lighter suit would reduce the inertia for movement and make it easier to stand-up.

Post-Summit Questionnaire Responses

The UCD was only used for EVA; operations on the lunar surface, etc. The CM was equipped with a relief tube. XXXX did wear his UCD on 13 and it resulted in a urinary infection. For EVA operations I don't see how you can improve the device.

Medical Kit

Medical Kit

1. **Considering the configuration and constraints of the CEV, do you think you could reconstitute a drug in that environment? In other words, if the drug was in a powder format, could you reconstitute it into a solution using normal saline or another diluent that would be provided in the kit?**

   This should not be a problem in microgravity and certainly not on the lunar surface.

   Post-Summit Questionnaire Responses

   Would be okay if the way was to add water.

   Yes.

2. **You mentioned in debriefs that blister packs were an issue because they expand during depressurization. We currently use pill bottles and Ziploc bags to pack medications into the current generation of kits. Using your experience and knowledge from Apollo, is there anything we would take into consideration with the design of the next generation of kits given the space in the CEV?**

   Provide items that are needed in daily life, such as lotions, band aids for minor abrasions, Tylenol, mild sleeping pills, etc.

   Having a physician crewmember would increase the comfort level.

   "Always have a doctor." cross train physicians to perform other activities on the mission.

   "Cross train fighter pilot to be a geologist on the moon."

   Post-Summit Questionnaire Responses

   Yes.

   a. **The kits for Apollo were very small and basic. What is your impression of the new kits today?**

   An example was shown and a crewmember commented on the large size and inquired about the contents. Dr. Jones stated that it contains blood pressure equipment, diagnostic capability, etc. More capability planned for the lunar kit to deal with contingencies.

Thought should be adequate.

Post-Summit Questionnaire Responses

Did not see it.

There is no question that a medicine to combat fatigue should be on board spacecraft. We took Dexedrine just before reentering the atmosphere to make sure its effect would stay with us throughout the landing. Take the medicine too early and their effectiveness would end and increase the fatigue. We were asked to take Dexedrine to combat fatigue. I did not because I was worried about a crash that might come when it wore off. It frankly was not necessary as the excitement of the upcoming entry and stress of the CM power up generated a lot of adrenalin. So I was very alert for that final entry phase of the Mission without any drug boost.

Bioinstrumentation

Bioinstrumentation

1. **Do you have any suggestions as to how we could improve the means by which we monitor (Heart Rate, metabolic rate) astronauts on the lunar surface, given our current system is almost identical to what you used in Apollo?**

   Wrist pulse monitors would be helpful. It would be good to have facilities for the crew to be healthy and well, especially if a physician crewmember is not a member of the crew. This

   would allow monitoring from the ground.

   The Heads Up Display (HUD) can overload people. It is not necessary crewmembers' blood pressure, etc. The displays should be simplified. consumables information and rate of use is okay. For other non-critical data, let a Caution and Warning bell ring, then check it out.

   Post-Summit Questionnaire Responses

   Yes. In addition to monitoring how about treatment.

2. **Upon reviewing the lunar surface films from the archives, it can be seen that the abilities to ambulate and perform tasks were a human factors challenge. In many instances you had to slow down due to physical exertion required for the tasks. Surgeon and Biomedical Consoles monitored this activity to help forecast consumables and overall stress on the crew. Given the advances in technology over the last 40 years, do you believe that if you were given accurate metabolic rate information and suit consumable data, that future astronauts would be able to "self regulate" their EVA activities in an autonomous fashion?**

   Yes this could help for missions on Mars.

   Post-Summit Questionnaire Responses

   Yes

3. **There were several times the suit Caution and Warning system notified astronauts that they were exceeding the thermal transfer capacity of the suit cooling system. During many of those times we did not see an excessive heart rate. The crew medical debriefs did not discuss this detail in depth since it was mostly a suit ECLSS issue. Do you recall anytime when you were really tired and the suit C+W was nominal or any circumstances when the C+W had a temperature warning and you were not tired?**

Post-Summit Questionnaire Responses

No, was never "very tired."

No., never happened to me.

Not on my suit Apollo 12

Environmental Impacts

Environmental Impacts

Environment and Habitability

1. **Temperature**

   a. How comfortable was cabin temperature in the CM and the LM? Cold, warm, OK, or depends on mission phase?

   The temperature was comfortable and never seemed to be an issue during Apollo missions. Crewmembers slept in the LCGs and didn't use a cover. It was more difficult during Gemini "because it was way too hot".

Post-Summit Questionnaire Responses

Yes. It was okay.

Yes. Way too hot? Not a concern.

The temperature was well balanced in the CM utilizing heat from the electronic systems and dissipating excess heat by a radiator. On 13, however, with most of the electrical systems shut down, we were losing heat faster than the sun could provide. The temperature gradually dropped to about 34°F by the time we reentered the atmosphere. We could have put on our pressure suits but they were too bulky for three men in the LM. It appears shuttle crews operate in-flight in shorts and tee shirt. If that will be the uniform on lunar flights, I suggest some thermal protection in case of electrical failure.

   b. What was the temperature control like in the CM while in the suits at vacuum on the suit loop?

   It was fine. The biggest temperature concern was staying cool and not getting sick before getting picked up at landing.

   On the lunar surface, the suits were very uncomfortable and should have been removed to get some rest. This could have jeopardized the mission.

   Be careful trying to design for the exceptional circumstance, need to train well enough to be able to react to the situation.

Post-Summit Questionnaire Responses

Yes. Okay

Yes. What is this getting sick?

c. Would thermal protective clothing have been adequate?

Yes, you should consider what is already onboard, maybe simply a thermal blanket. If the suit was easier to get on, it wouldn't have been an issue.

Some crewmembers stated that they wish they had taken the time to unstow the suits.

Post-Summit Questionnaire Responses

Yes

One can certainly design for improved sound suppression and add thermal blankets that would support an emergency power down such as we had on Apollo 13. The issue is added weight. That would have to be a part of a design trade study. Trying to provide comfort like at home and handling extreme emergencies might compromise accomplishing the basic mission because of weight growth.

2. Waste Management

a. Did you have any experience in the development of the "fecal canister" in the CM and do you know why it was never flown?

It worked fine, however it could have been a little bigger.

Diarrhea needs to be prevented in 0 g to eliminate mess and time-consuming cleanup. Systems should be designed differently for 0 g versus positive gravity.

First determine what should be used on the moon, then work on the vehicle.

Post-Summit Questionnaire Responses

No.

No. There was no fecal canister--just bags.

b. The urine collection device caused problems on virtually every mission. What specific problems did you encounter?, What are your recommendations for improving the device for CEV/LSAM waste management systems?

There were no problems with the UCD, however you want to sit on the moon not strap a bag to you. Have to know not going to move bowels on EVAs. Dr. Kerwin suggested using the Skylab system, since it worked great in 0g and in 1/6 g it doesn't need airflow. Problem solved! All participants concurred. System must be customized for both men and women. Diaper is good for urine during EVAs, however cannot defecate in EVA suit.

Apollo 8 did a urine dump and it turned into snow. It was a navigation issue.

"The Agency is trying to make everything perfect." It is not possible to think of everything that may go wrong. "Crewmembers are willing to suffer under certain circumstances."

Post-Summit Questionnaire Responses

Yes. Did not have a problem Yes. Don't poop!!

c. Was it acceptable to have a bag for outbound and return, as long as there was no "off-nominal output"?

Off nominal output was dominated by surface tension. It adhered and moved. Fix it!

Post-Summit Questionnaire Responses

No Responses

d. Waste management issues dominated much of the debriefs. The crews reported that they felt it “uncivilized”. Although it depends on the crew, some crewmembers stated that they considered themselves explorers and felt they could put up with anything. That might be why some debriefs did not have complaints. You can put up with anything for two weeks, but it would be different on very long-duration missions. What can we do better, other than make the bag bigger?. We know mixed crews will also complicate things.

Calcium balance studies were being done that required crewmembers to collect waste.

Don't make it a requirement to save it, just dispose of it all, including the blue bag.

Everything would be fine if crewmembers had the time to do it, could clean it up, and didn't have to save it.

Post-Summit Questionnaire Responses

Yes. Not a big problem. Dispose of collection bag before entry. Yes. Uncivilized? What the hell is this!! Take them camping in the woods for a few weeks!! Wimps need not apply

e. **Do you feel a need to separate your area for food preparation (galley) from waste management? It was designed to take up limited space. What should be done about this?**

The crewmembers felt there was no choice in this situation.

Post-Summit Questionnaire Responses

No. Nothing

Space limits dictate. We can live with that.

Yes. Separate for the weak of heart.

Noise/Acoustics

1. **Noise level in the CM was unacceptably loud, interfering with sleep periods. What mechanical systems were responsible for the noise (e.g. cabin fans, glycol pumps)?**

Inverters were noisy, but a pleasant. sound because it meant everything was working. Earplugs worked. High screeching noises were unacceptable.

Crewmembers didn't seem to be too concerned with the noise and stated that it did not keep them awake. The absence of sound would have been more uncomfortable.

Minimize noise, but don't eliminate it. There are noise-canceling devices today.

Post-Summit Questionnaire Responses

No. I liked the background noise for sleeping.

Yes. White noise is good.

I personally was not bothered by the noise level in the CM on 8 and the CM was shut down on 13. It seems to me, the orbiters being much larger than the CM the noise levels should be lower. On Apollo, we had ear plugs for communications and were helpful in reducing noise to the ear.

a. **Was there a threat to hearing?**

No, there was not enough sound to threaten hearing. The iPods are a concern now, but didn't exist on Apollo.

Post-Summit Questionnaire Responses

Yes.

2. **Was hearing protection or noise attenuating devices available for the crew? Did they work adequately?**

Post-Summit Questionnaire Responses

Had none. Needed none. (Maybe that's why I'm deaf now.)

No.(no hearing protection was used)

We had the Snoopy earphone caps -I never was bothered by noise.

Don't think so, but would not use anyway.

Not available. Not needed

Sleep

1. **Some crew preferred being wedged into something to feel secure for sleep. The sleep restraint system was outstanding. How can these important considerations be incorporated into the CEV/LSAM design, based on your experience in the CM/LM?**

There is good technology today. No reason to re-invent the wheel."

After approximately 3-4 nights of adaptation and excitement, gave in and went to sleep.

Pillows and comfort items are important.

Sleeping in the hammock was comfortable, although frequently awoke to check things. 1/6g solves problems.

Post-Summit Questionnaire Responses

No. Used hammock for about 3 days, then did not bother with it. Slept mostly in couch after that.

Yes

The sleep restraint system worked fine in Apollo and I suspect they worked just as well in the orbiters. For lunar surface, hammocks could be rigged in the LM. You will have to ask others on how good they were.

a. **Are there any other comments about sleep, besides the ones discussed above?**

One crewmember reported a loss of proprioceptive that kept him from going to sleep in the first rest period after launch. He realized he could not feel where his arms and legs were and how much muscle tension it took to get them back. This only occurred during the first sleep period and he never noticed it again after that.

That first half hour rest period was a "fascinating experience".

Another crewmember stated that using the restroom at night always woke up other crewmembers.

Post-Summit Questionnaire Responses

Fetal position felt good for sleep but the sleeping bag allowed only one knee to be raised at a time. (l) Make sleeping bag large enough to get both knees up, (2) Provide strap to hold knees up. As I drifted off to sleep, I would release my knee & it would wake up.

Yes

Air/Atmosphere

1. **The lunar crews stated the moon dust had a distinct "wet ashes or gunpowder" odor upon return to the LM. Were these odors/fumes noxious, i.e., did the crew experience any reactions to this odor?. Was it cleared by the LM ventilation? Were there other sources of dust and particulates in the CM or LM? Was lunar dust noticeable in the CM?**

See dust issues above.

Post-Summit Questionnaire Responses

Yes

a. **Were there any problems with air or water quality? Was there a need for point-of-use filtering or biocide? For air contaminants, what would you recommend that we monitor for?**

CO_2 levels should be monitored in the air.

Chlorine in the water was an issue during one early Apollo mission, however it was resolved in later missions.

Crewmembers didn't notice a problem with the water if it was mixed with food. Chlorination and ionization technologies should be reviewed for future missions.

Gas-permeable bags had bubbles, but this has been resolved.

Chlorination is not an issue now. Information can be obtained from the debriefs.

The crewmembers reported headaches and wondered if they were caused by CO2.

Post-Summit Questionnaire Responses

CO2 most important.
Yes.

b. Were CO2 measurements reliable?

CO2 monitoring was unreliable and the readings were no good.

Post-Summit Questionnaire Responses

No. Didn't know this!!

Microbial

A discussion was held regarding the build up of microbials in closed vehicles and how this would be managed. Topical wound care treatments, such as Neosporin, should not be used routinely, but only for high-risk wounds that are at risk for infection. There may be changes in wound healing during space flight, so it is not yet known how this will be handled for future exploration. Topicals were more resistant to loss of potency. This is a big issue for long-duration space flight. Topicals will be available, but not necessarily used for routine wounds.

It is not known if antibiotics will remain active and useful in space. One audience member commented that it may be like "Civil War" medicine without antibiotics. If one crewmember had an organism, all the others would get it.

Dr. Fischer stated that we don't know how absorption occurs during space flight. This is a major issue that needs to be addressed. Dr. Jones stated, however, that there have been some cases of in-flight infections that have been successfully treated with the medications flown. There is more capability now and prevention is the best approach. A different design is needed for urine collection.

Stowage/Layout

1. **In emergency suit donning cases such as cabin depress, was there adequate time to allow retrieval of suits, to install the docking hatch, to reposition the seats, etc.; if new designs would have helped, any suggestions on how to reduce the amount of loose equipment that must be found and installed, etc.**

   Design a plan to don suit rapidly.

   It must be done sequentially (Note: unless cabin volume accommodates two crew donning simultaneously)

   It might have been possible to do two at a time donning the suit, but it still would have been difficult.

   A self-sealant is necessary.

   (There was an additional, emergency garment during Gemini 7.)

   Post-Summit Questionnaire Responses

   Yes

   Yes. Depends on leak rate, but why is he pressurized?

2. **Docking hatch opening and stowage options**

   Make sure the hatch is created to comfortably accommodate a crewmember in a pressurized suit.

   Post-Summit Questionnaire Responses

   Yes

   Yes

3. **Stroking pallet (struts up vs. down); clearance options for moving about underneath and for potential maintenance / IFM scenarios**

   Do what is ideal for the mission. Obviously, space is needed. The Command Module is good.

   Post-Summit Questionnaire Responses

   Yes

   Yes

4. **Were there any issues/lessons learned with respect to reach or field of view to switches, controls, windows & displays during high-g and zero-g; did you participate in any ground-based centrifuge or zero-g flights and how did that prove useful in the design of these areas?**

   0 g was an asset when trying to reach for things. Take advantage of 0 gravity in designing.

   The CM was confined, but still had reaching ability.

   Get more astronaut participation at the design phase. Need to have operational consideration during the design and development stages.

   Post-Summit Questionnaire Responses

   Zero-G flights most useful. Better than pool for many operations.

   Yes

5. **In the case of a side on landing on a wave or ground landing of the same, would the Apollo seat and restraint system have been adequate; any suggestions on how to design it now?**

   Post-Summit Questionnaire Responses

   Do not do ground landings unless you want to kill the crew(s). Seat design should allow for impacts on waves.

   Keep the seat belts tight! Don't overly complicate it. Look at Russian designs.

   Yes. I believe the system would have been okay. We did not stroke seats on landing with 2 chutes.

   Apollo design was good for both!!

6. **Recommendations on stowage of items in irregular spaces/in creative ways; how would you design it now?**

   Post-Summit Questionnaire Responses

   Think about putting REID tags on each (or each important stowage item. This would allow quick electronic indication of each item's location; even if misplaced after initial stowage.

   Stow items as needed in volumes

   Yes

   Apollo was good!! Map

7. **During EVA prep or post, were there any issues with umbilical plug-in locations, tangling with other umbilicals & people, umbilicals too short, long, correct number of each, etc.**

   No significant issues on LEM, but give plenty of space to don/doff.

   Post-Summit Questionnaire Responses

   Okay

8. **Describe challenges of nominal and/or emergency suit donning in zero-G & suit stowage, given the small size of the spacecraft.**

Post-Summit Questionnaire Responses

Practice, practice, practice, Apollo 16 crew did don and doff at least 6 times in LM simulator.
It was tight but doable. 0g feels like bigger space than 1g.
Tight quarters no big problems.
See 7 above.

9. Describe any limitations or good points in the use of the windows to see the horizon during nominal and off-nominal ascent/entry as well as their use in viewing the LEM docking target during a rendezvous.

Post-Summit Questionnaire Responses

Windows should be designed to see what you need to see to land and/or rendezvous and no more

Yes. Good visibility for docking. Used horizon as Entry attitude, Good!

Apollo was adequate.

Be very careful about Pls who want to have windows without IR protection. It's an insidious trap with potentially serious consequences a filter.

10. Can you describe egress, human factors issues that have crew health and safety impacts?

Post-Summit Questionnaire Responses

The egress ingress of the LM was the most difficult because you had to arch your back over the ascent stage engine bell in the cockpit.

None, not anticipated.

Question is, what!!

11 Are there any suggestions to create privacy for mixed crews during the waste and fecal collection processes; how was privacy created during Apollo, did you go under the seat pallet, use fabric barriers, etc.

Post-Summit Questionnaire Responses

No privacy allowed. No room for it. Providing privacy in the CEV is dangerous to crew survival. The CEV should be 4.5 meters max diameter.

Just went to LEB -but tbr space, not privacy.

No. We were ready for this and did not seek privacy as I recall.

No privacy -but how do families live? Some privacy required -private space vs. practicality -don't be bashful!!

12. **With regard to having hot & cold water and a food warmer, how important is it to have these items vs. the precious space they occupy in the tight cabin confines; would this be considered a necessary comfort item in cases where there a lots of crew in a small space for several days, i.e., 6 crew to ISS?**

    Post-Summit Questionnaire Responses

    Not a big deal. We had it in Apollo

    We had hot & cold water. New meals w/warmer would be nice but not critical.

    Hot & cold water is a must -food warmer is desirable.

Radiation

1. **With regards to lunar surface operations, in the event of a solar event, can you describe any difficulties you may have had returning to a safe haven? What ideas can you offer on creating a safe haven in a remote area?**

   Put shielding that you can pull out on your rover, or maybe something you can hide under-perhaps dig a trench and sit in it.

   Post-Summit Questionnaire Responses

   Yes

2. **Medical operations and regulatory requirements mandate that each crew wear a crew personal dosimeter (small device that measures radiation exposure level at the surface of the body) at all times throughout the mission. The crewmember's evaluated exposure could be artificially high or low if the CPD is not worn. Can you suggest pre-flight or in-flight actions that would improve crew compliance with always wearing CPD?**

   Post-Summit Questionnaire Responses

   Attach it to suit garments so the crew persons don't have to locate it, find it and put it on. Make it invisible?

   No. Training!

We always wore ours. Make it a mission requirement.

3. **The crew can play a crucial role in managing their in-flight radiation exposures. This could be as simple as sleeping in well-shielded locations. Do you agree that the crew should actively manage their radiation exposure during a mission by monitoring their exposure and modifying their shielding? If radiation protective nutritional supplements or pharmaceutical agents were approved for spaceflight, would you consider using them?**

   Yes having the information about incoming radiation could help.

   If protectants can work or reduce the health impact, then yes, we should have them available.

   Post-Summit Questionnaire Responses

   Yes

   Yes

4. **Current radiation detection technologies provide the ability for crew readout of real-time radiation levels, customizable alarms, and "hot and cold spot" mapping of the vehicle's habitable volume. Do you have preferences or advice on how these readouts or alarms should be designed? Would you have found this information useful during enhanced space weather events (SPEs)? Or during times when there is a loss of communications?**

   Should have active radiation detectors with alarms that sound when the dose gets too high for safety, so you can get back or find a safe place.

   Post-Summit Questionnaire Responses

   Yes

   Yes

5. **Active radiation monitoring either integrated into the suit or a rover would provide necessary dose information (i.e., rising radiation levels during a SPE) while EVA to provide for operational decisions that would work to ensure that the crewmember's dose is maintained within limits. Would you have a preference for where the monitoring device would be located?**

They should be attached to each suit.

Post-Summit Questionnaire Responses

Yes. Each suit
Yes.

a. There is a plan for warning dosimeters as a means of early radiation detection and alert. How do you feel about this?

There is no problem with having these on the suits, however it may be too late once the alarm sounds.

How do you get a true forecast and warning system? It would be interesting to have more details.

Post-Summit Questionnaire Responses

Early warning is key.
Yes. Solar flare detection is a must.

b. Advance warning is currently very limited and there are issues with donning suits rapidly and plugging in umbilicals. How could this be made better?

The crewmembers did not remember problems with the connect/disconnect systems.

They had no problems in training or with the attachments and the disconnect systems may be even better now.

They were hot miked during prep and de-prep and those transcripts are available. Comments would have been made if there were problems.

It would have been difficult to get the suits on any faster than they did. If they tried too quickly, such as in the case of an emergency, they would have skipped some checks.

There were issues with waste management. Going back to the moon would be like "camping out", but Mars would be a problem.

Post-Summit Questionnaire Responses

No problem with normal donning -Don't have experience with panic mode.
Yes.

Exercise

Exercise

Exercise and Fitness

1. **Did you feel physically fit prior to the mission, and did you have good strength and endurance while on the lunar surface?**

   Post-Summit Questionnaire Responses

   Yes, we had exercise protocols in the ground and glove boxes to strengthen your hands.

   Yes and N/A

   Yes

   Yes, but I slept poorly -If I could do it all again, I would take a sleeping pill (I do not use them on Earth).

   Yes.

2. **Did you feel more 'winded and fatigued' that you expected? Did you feel more unbalanced' or uncoordinated than expected while working on the surface?**

   We got tired, but we were pumped up with adrenaline. Probably would wear off for long missions.

   Post-Summit Questionnaire Responses

   No Responses

3. **What do you see as the role of pre-flight conditioning? What is your opinion of its importance to mission success for these sho**rt **duration trips?**

   - Make requirements known and plan time in the schedule to meet them.
   - Loosen the timeline.
   - Apollo crewmembers always scheduled time for running. Strength exercising was done at night on our own.

   Post-Summit Questionnaire Responses

   Good comments

   Yes.

4. **Are there any aspects of your preflight or in-flight exercise training that you would change to better prepare you for your mission tasks?**

   Post-Summit Questionnaire Responses

   No.

   People are bright -give them imagination & they'll take care of themselves.

   Size the flight suit slightly longer than the training suit. There must be accurate data by now.

   No. Training adequate.

5. **In terms of physical capabilities -what were the hardest and easiest tasks that you had to perform during lunar EVAs?**

   Repetitive hand gripping and forearm activities. Getting things out of the cases when they had been baked in was also tricky.

   Post-Summit Questionnaire Responses

   No Responses

6. **Were there any physical tasks that you couldn't do or had to modify substantially from the original mission description due to fatigue or injury or other factors?**

   There was some mental fatigue.

   "There were short periods of time when mental attitude went into idle because there weren't any exceptional observations."

   Post-Summit Questionnaire Responses

   Not for me. (no mental fatigue)

   Yes.

7. **Was your task load and recovery time coupled well for your mission as a whole? Was it coupled well on a day-by-day basis (versus too easy or too hard)? If not, did inadequate rest between demanding tasks contribute to fatigue and/or injury?**

   Have two teams working EVAs on alternate days.

   Give crewmembers time off with no responsibilities.

   EVA day should not be all planned out.

   Give objectives and allow crew to dictate their day to accomplish their tasks.

Post-Summit Questionnaire Responses

Yes.

a. **During EVA day would it have been better to have a break during an EVA? Go out and come back in and go back out?**

Do not break a day in half at all. Once out there, get it all done, no interruptions. If you

have a suit that can allow you to be out longer, there might be a concern.

Once you get into a project you lose track of time. Contact with the ground is necessary and you have to have discipline.

Post-Summit Questionnaire Responses

Yes.

8. **Given your physical condition immediately post Landing, would you have been able to (1) egress unassisted from the Apollo capsule and (2) assist an injured crewmember with egress in an off-nominal, emergency scenario?**

Yes, we could have gotten out, as well as assisted an injured crewmember.

Felt physically fit enough to do this unless there were high seas-could not do in those cases.

Post-Summit Questionnaire Responses

Yes

Yes.

9. **How long did it take to return to normal daily activities following the mission?**

- One crewmember felt normal almost immediately. Generally returned to normal activities within 48 hours.
- Another crewmember stated three days later he felt normal.

Post-Summit Questionnaire Responses

About 3 days to feel normal. About 2 weeks to fully recover conditioning.

Yes.

In-flight Exercise and Hardware

1. **The Exer-Genie is mentioned in several of the debriefs. Did you use it? If so, in what configurations, for how long per session, and during what mission phase (e.g., surface, outbound, return phases)? Can you expand on its negative and positive impact? Do you think it was helpful in maintaining fitness or strength?**

   - The consensus is you don't need exercise on short trips (14 days or less).
   - Exercise is important preflight.
   - EVAs provide enough exercise.
   - Having it there is fine for those who want it, should not be a mandatory protocol to use it.
   - It is useful to have the knowledge that there are certain exercises to reduce fatigue.
   - Exercise feels good.

   Post-Summit Questionnaire Responses

   Yes. Didn't work after a couple days. Retained heat.
   Yes. Learn how to use the device

2. **Exercise was reported to improve low back pain during the mission. Crews mentioned specific exercises but were unclear how they performed them. Can you describe the types of exercises you performed? Considering the design for the CEV/LSAM, can you explain how you might perform them in this environment? Did it help with back pain or stiffness related to confines of the vehicle?**

   In addition to the Exer-bike during early Apollo, we did some running in place and isometrics. It can relieve less in your muscles.

   Exercise should be available without getting in the way of the other crewmembers.

   Post-Summit Questionnaire Responses

   Yes. Used outer couch rails to do pushups. Moving back as in sit-ups helps.
   Yes

3. **The crews mentioned that they did not want to perspire during exercise in the cabin, and backed off on the intensity to prevent perspiration from forming. What was your concern with perspiration?**

   Hygiene was a concern because there were no showers and not a lot of towels. We didn't have these wet wipes to clean up with on the earlier missions.

On later missions the "wet" wipes had a bad odor.

Post-Summit Questionnaire Responses

Don't recall a problem. Filter good at removing odors.

Yes. No concern.

4. Were there any stress relief/psychological benefits from using the Exer-Genie? Did its use impact other crewmember activities (due to small space in which exercise could be performed)?

Yes the exercise can be a stress reliever or just put you in a better mood. Exercise can have a beneficial effect during the whole mission, just don't have specific schedules for it, let us do it as R&R.

Post-Summit Questionnaire Responses

No

Yes

5. Do you think formal exercise is required on a two-week lunar mission to perform EVA tasks and to maintain fitness for egress on return?

- Should not be a man mandatory protocol
- Should be physically and mentally ready
- "Would like to through by people who understand muscle."

Post-Summit Questionnaire Responses

Helps relieve minor aches, but not necessary on short flights.

No not required.

a. The crewmembers have indicated that they do not want scheduled exercise periods on the timeline. They want to exercise on their own time. Is there anything else to add?

No exercises were done for bone density during Apollo. This would be a problem on long-duration missions.

When the Exer-Genie was no longer used, crewmembers performed push-ups and ran in place.

Post-Summit Questionnaire Responses

Yes

6. **Volume and upmass will be limited in exploration vehicles/habitat as it was on the Apollo vehicles. Given the limitations this will impose on possible exercise devices, are there any specific types of exercise (stretching vs. aerobic vs. resistance-type) that should be a priority for lunar sortie and lunar habitat missions?**

Post-Summit Questionnaire Responses

Aerobic probably the best for long duration surface missions.

Watch out for devices that depend on friction -ours got so hot that it eventually destroyed the cord. It's dangerous.

No. Stretching best

Don't know

Any exercises that can be provided WRT space -h EVAs provide enough

7. **Apollo 7: The crew suggested the Exer-genie could use some improvements. What type of improvements would you recommend and how can these improvements be incorporated into the devices planned for CEV/LSAM?**

It needs to be reliable and simple to use.

Post-Summit Questionnaire Responses

No. Good device on Earth. Need something else in space.
And know how to use it.

   a. **A more robust (and lightweight) piece of equipment is needed. Are there any comments to help in development?**

Put as many capabilities in the vehicle as possible, because it will get used. Exercise throughout flight will be critical. A variety of exercises must be provided.

Post-Summit Questionnaire Responses

Yes.

8. **Several crews stated that the exercise device got hot during sub-maximal use. The heat generated prevented stowage secondary to the crew's concern of a fire hazard. What part or parts of the device generated this heat? How would you suggest designing the device differently to obtain maximal workloads and be safe, considering the mass/volume constraints of the CEV/LSAM?**

   Heat was generated in the rope.

   A crewmember asked what will be done one week prior to returning, in order to counteract SAS during short flights. It was explained that high-intensity training will be used. The body should be worked hard so it counteracts orthostatic intolerance.

   The blood volume needs to return to what it was originally.

   The ASCRs work with the crewmembers individually and provide prescriptions for exercise. Although they do not monitor them daily, they do provide a program for them to use.

   A discussion was held regarding how to get cardio for the entire pulmonary system with the differences between 1/6 g and 1 g?

   G suits were discussed. The Russians use lower body pressure cuffs.

   Exercise must be performed on the surface, as well. Decrements have not been completely eliminated in space flight so far.

   Post-Summit Questionnaire Responses

   See above -Friction of rope on control spindle -inherent to design. Don't depend on friction on a small surface.

   The rope on our Exer-Genie stretched. Friction clutch got hot

   Yes

Food/Nutrition

Food/Nutrition

1. **Initial allocation of space for food supplies on Apollo missions was 5003 cubic inches. Baseline food and packaging requirements were 4830 cubic inches. Over time, the food system volume values increased. By Apollo 14, the average volume/man/day was 188 cubic inches. This equates to a total of 7896 cubic inches required. Where was the extra food stored?**

   - The regular meals were stowed in one compartment in the left hand equipment bay.
   - The problem was not stowage, but it was the garbage requiring twice the volume of the initial stowage.
   - The radiated food was in foil and there were no hard containers.
   - There was a lack of flavor or spice in the food. The bacon squares were the best food. It was something to stimulate the taste buds and for the flavor itself.

   Post-Summit Questionnaire Responses

   Yes

2. **How did the additional 2893 cubic good get stored? Was all the food stowed together? Were only hard-sided containers used for food storage?**

   See #1 above.

   Post-Summit Questionnaire Responses

   don't remember

3. **If you had to rank the overall importance of the contribution of each of the following to eating during flight how would you rank (very important, somewhat important or not important): 1. Lack of taste; 2. Lack of time; 3. Don't think it's critical if I lose a little weight; 4. Don't particularly like the food; 5. Food is somewhat difficult to prepare; 6. Sometimes nausea or gastrointestinal distress makes eating unappealing; 7. Lack of "social" interaction detracts from food intake.**

   Post-Summit Questionnaire Responses
   The normal newer MREs are adequate. Rating the above is weird.

   6 5 1 2 4 3 7

   (1) v.I., (2) N.I., (3) N.I., (4) N.I., (5) I., (6) N.I., (7) N.I.
   (I) Very important, (2) Very important, (3) Somewhat important, (4) Very important, (5) Very important, (6) Very important, (7) Not important.

(1) Somewhat important, (2) Not important. (3) Not important -drink water, (4) Not - you select your own, (5) Very, (6) Not, (7) Not.

4. **There is some discussion not to have hot or cold water and/or a food warmer on the CEV.**

   Hot water is an absolute necessary on both vehicles.

   Hot food is more comforting than cold food.

   Find out how the original wet packs were put together.

   Post-Summit Questionnaire Responses
   Hot food is very important. Warmers may not be critical. Yes.

5. **How important would you say heating your food was/will be during a short duration mission (less than 7 days) or a longer mission (more than 7 days)?**

   See #4 above.

   Post-Summit Questionnaire Responses
   Very important

   Yes.

6. **How important would you say cooling your food items was/will be during a short duration mission (less than 7 days) or a longer mission (more than 7 days)?**

   Post-Summit Questionnaire Responses

   Unknown -Preservation for fresh items for long missions will need a refrigerator.

   Not critical

   Cool what? -ice cream -water -ice tea! Get real.

7, Were there any vehicle environmental changes during a mission that you recollect there being a change in food temperature that was either positive or negative?

Post-Summit Questionnaire Responses

No. No.

RG: No.

8. **Was there any concern on the relative locations of the hygiene and waste areas and food stowage/galley area?**

   No we had to eat in the same place we pooped, but that is not the best situation, we just had to do it.

   Post-Summit Questionnaire Responses

   No.

   Yes.

9. **Was there any issue with EVA performance due to quantity or quality?**

   Lunch and plenty of water was needed on EVA

   Post-Summit Questionnaire Responses

   No.

   Yes

10. **It has been reported that bread packages often burst when the vehicle was depressurized, There was also report of an incident with chocolate pudding.**

    Post-Summit Questionnaire Responses

    Fix the packages. No real problem.

    a. **Did you observe other products (especially wetpacks) that also lost packaging integrity during this time or at any other time during a mission?**

       No regular packages had any problems.

Post-Summit Questionnaire Responses

No.

The LM water gun leaked because a thread from one of our beta cloth garments or stowage bags got lodged in the valve opening. It was a very slow dribble. After getting fixed, it did not impede our delivery of H2O. I feel we got dehydrated because we lost our hot water source when we shut down the CSM. As a result we did not subsequently consume any of the powdered, freeze dry food and hence a loss of a lot of water one gets that way. We lived off the "wet packs" and cookie & bread cubes from the snack area. Secondly, with the low work load floating around in Zero g and the cold environment we just didn't get as thirsty as we normally would. I know that Jim is quoted as saying that we deliberately rationed our water. I can state that I did not ration, but obviously did not consume as much water as I should have.

b. Were you instructed to discard these items?

Post-Summit Questionnaire Responses

No

No

11. Apollo 10: How would suggest developing meal plan/food choices for time-critical activities to allow you to get necessary calories and fluid in a convenient manner?

Post-Summit Questionnaire Responses

What we do now in the Shuttle is adequate.

A-12, 13, 14**,** 15, 16, 17. What's with 10?

12. Did it mean anything to be able to see the food through the packaging?

It helped to pick some things out, usually we could only tell by the labels.

Post-Summit Questionnaire Responses

No. Labels were okay.

No. You selected the menu.

13. Did you crave certain foods or types of foods?

Spicy and salty foods.

Post-Summit Questionnaire Responses

Coffee

Bean needed pasta.

a. Was the food bland? Would you have preferred spicier foods?

Not if it would cause a diarrhea problem.
Just more flavor in the foods.
A crewmember commented that they were told they would get individual menus, but that did not happen.

Post-Summit Questionnaire Responses

Yes, more taste

No.

14. How important was it for you to time out at least once a day and eat together?

We were on the same schedule for eating, sleeping, etc.

Post-Summit Questionnaire Responses

No. Very

Yes.

15. Did the lack of appetite or space sickness affect your performance during the mission?

Post-Summit Questionnaire Responses

No

No

You betcha! But/and it went away.

Yes on Skylab for 4 to 5 days.

No.

16. What do you consider to be the major impediments to eating and maintaining weight during flight?

Post-Summit Questionnaire Responses

An overly ambitious timeline
Time to do it
For me SMS
None. if you eat your plan.

Food taste and the time it takes to prepare and clean-up Eating ok, dehydration

It's my impression that the food in Apollo was uniformly OK preflight and absolutely unattractive in flight. I did not have that experience in Shuttle. Makes me think it is either O2 toxicity, reduced pressures, or, less likely, unaccelerated flight.

a. The crewmembers lost weight routinely…some lost 8-10 pounds. What can we do to make the food more palatable?

We were debriefed extensively. All of this information is available.

Post-Summit Questionnaire Responses

Weight loss was mostly due to sweating, & air cooling after landing in suits in the ocean. If liquid cooling was available, the loss would have been 2 lbs at the most.

TV dinners would be good.

Yes. Weight loss!

b. How important do you feel that it is to get sufficient calories in a day? Please provide an example (if any) of the importance of nutrition and food intake.

You need enough food to maintain your strength and alertness. One crewmember didn't lose any weight.

Post-Summit Questionnaire Responses

Yes. Need the energy

Yes. Adequate calories provided.

c. **Do you feel that it is important to have a preflight eating plan that optimizes nutrition for the best possible nutritional status before flight?**

Post-Summit Questionnaire Responses

Sure

No.

Just have the food taste like what it says it is.

Yes

Maybe

Yes

d. **What is your attitude about supplements in general? If you were shown data that a supplement such as omega 3 fatty acids would be protective against certain health issues would that convince you to take the supplement?**

Supplements could be good if stowage is a problem, no issue with using them.

Post-Summit Questionnaire Responses

No

Yes

Yes

e. **Would data on the timing of exercise to food intake affect your behavior if shown that one type of eating pattern helped to maintain muscle mass more than another eating pattern?**

Post-Summit Questionnaire Responses

Probably not

No

Maybe

Yes

Yes,

maybe

Yes

f. How important do you think optimal diet and food intake is to your overall performance?

Post-Summit Questionnaire Responses

Not very on short duration missions.

For long missions, it is important.

Adequate is good -nothing more here.

Very

Very important

Very

g. How important do you believe that rehab post flight might be if optimal diet and exercise were combined?

Post-Summit Questionnaire Responses
Not needed for lunar surface ops if crews do EVAs as much as practical.

Very

Very

h. Considering current packaging configurations, do you believe there to be any advantage/disadvantage relate to preparation and consumption as compared to Apollo-type packaging?

Wet-packs.

Post-Summit Questionnaire Responses

Packaging much better now.

Skylab cans were better -bags are tough -not appetizing.

Don't really know

Yes

i. Though rehydratables and wetpacks (currently known as thermostabilized and irradiated) required more resources than bite-size (cubes) items, do you believe there were specific bite-size items that were of high enough quality to compete for selection/provisioning?

Wet packs were best. They were good and they were easy to use. Rehydratable foods were fine. We liked most of the foods. Basically, it was trail food. It is probably much better today than it was then.

Post-Summit Questionnaire Responses

No, maybe snacks

Yes

Pharmaceuticals

In response to a question from a crewmember about how to qualify a pharmaceutical for space flight, Dr. Jones explained that most medications are tested on crewmembers prior to flight, however this does not account for possible altered characteristics in a new environment.
Dr. Fischer stated that there is no evidence that drugs have had different effects in space than on Earth. It may be necessary to alter the dose and/or the route of delivery, but it has the same effect.
Dr. Pool stated that we do not have a well-established understanding about this issue and we need to obtain the information somehow. We must target the specific information that we want, obtain the norms, and get an idea of what to do.
A number of experiments will take place, including **bisphosphonates.** This drug is really not intended for this population, but rather for osteoporotic women, so it is unknown how it will effect this population. We will be looking at calcium excretion and other bone markers, etc.
We will need to be able to archive urine and blood. We will also be looking at hydroxyfolie.

Crew Work/Rest Schedules

Crew Work/Rest Schedules

Sleep and Fatigue

1. **The Apollo 15-17 lunar crews felt they were able to sleep and function adequately in the LM during the lunar surface ops for their 31+ hours on the moon, although they didn't sleep more than 3-4 hours at a time. What changes would the crew make in the LM to preserve sleep/daily activities for missions of 7-14-30 days? Should there be a hard fixed sleep period of 8-10 hours? What would be a nominal workday length?**

    - Give crewmembers a scheduled sleep period (eight hours of rest where nothing is scheduled).
    - Staggered sleep distracts others from sleeping when one crewmember is moving around.
    - Cannot dictate sound sleep, but must give crewmembers private time.
    - A crewmember commented that "Circadian rhythm has nothing to do with space."
    - Changing back and forth (sleep shifting) is not desirable

    Consider mental fatigue and physical fatigue separately. Although there was not a great deal of physical fatigue, the mind was being used quite a bit. You can sometimes wear your brain out before your body is fatigued.

    It took about 3 days to get adjusted to weightlessness and be able to sleep. The head is not stabilized on the pillow in 1/6 g, So you feel like you're falling off, but you get adjusted to the feeling.

    There are terrestrial examples of circadian rhythm shifts in new environments (i.e., long-duration cave habitation). There are shifts when you leave the Earth's surface.

    In space, the Schumann Resonance Frequency (SRF) must be considered. Discussions should be held with experts who have studied this.

    The impact of the workload of mission control support personnel is also a factor. They need defined sleep periods and time off to keep the mission functioning.

    It might be worth looking at the work cycles of Mission Control operations during Mir.

    The crewmembers commented that the Apollo 13 crew was still able to function, even though they were the most sleep deprived of all missions.

    The flight surgeons should be advocates for the crews.

    The 8-hour sleep period should not be compromised even if the crew doesn't use all of it because they are just dozing part of the time.

Post-Summit Questionnaire Responses

Yes

2. **The crews slept in their suits during surface ops for Apollo 11 through 14 and reported that suit discomfort led to a poor quality of sleep. Apollo 15 and subs slept outside of the suits, yet still reported less-than-optimum sleep. Can this be attributed to scheduling, environmental noise, lighting, tasks, ground communication, sleep shifting or difficulty in relaxing in a strange environment, or did other factors contribute?**

Post-Summit Questionnaire Responses

I slept great. If folks are worried about the machinery failing, they won't sleep well. Even with pills, Charlie didn't sleep too good.

Fear of not being alert if an emergency came up -This can't work for long duration stays.

3. **Sleep deprivation and fatigue caused by a host of factors was mentioned in medical debriefs. These factors included excessive cabin noise, comm. interruptions, sleep shifts, cold temperatures, and staggered schedules. How was crew performance and morale adversely affected by sleep deprivation and fatigue? Were critical operational activities impaired (e.g., TLI and TEI burns, lunar orbit, re-entry preparation)? What suggestions do you have to avoid such problems on future lunar missions?**

- Apollo 13 , were most affected by sleep deprivation, but were able to perform.
- We stuck to the plan. Didn't feel anyone wasn't performing to their level. It was not an issue.
- More attention was paid to the schedules than to crewmembers' sleep time.
- At one point, the decision was made to stop work completely and go to sleep on Apollo 13. There was a physiological and mental need to stop and sleep so we told the ground stop we have to go to sleep. It turned out to be the best decision in order to continue. Mental fatigue is a bigger factor than physical.

Post-Summit Questionnaire Responses

Apollo 15 crew slept at same time -and on Houston time. Made normal work day and sleep much easier. No diurnal shift.

Yes

4. **Nearly all Apollo crews reported being tired on launch date, and medical debriefs indicate an intense pre-launch training schedule that caused fatigue, Can you suggest a reasonable training schedule 6-8 weeks before the launch date that will allow crews to launch adequately rested?**

   - The last week of training was mentally fatiguing because continually training for things that would not occur. The training schedule should allow for crews to concentrate on things that will be used for the nominal mission.

   - Contradictory comment: "Don't remember saying they were tired at launch."

   The crew planning timeline is critically important. Private communications have revealed a sense of frustration in crews trying to fit everything in. There must be a suitable plan in order to avoid serious operational problems caused by fatigue.

   Dr. Pool stated that we should not take what was done during Apollo and use it as a model for Mars.

   The crewmembers pointed out, however, that the lessons learned during earlier Apollo missions were helpful in later missions. The problems were still present during Skylab, however the timeline again improved in later missions.

   The crew schedule should have slack early in the mission to allow time for learning/training.

   The crewmembers reported that they were fatigued on launch day, due to the timeline for pre-launch training. They felt that much of the mental fatigue was due to the amount of non-essential training that was not operationally relevant.

   One crewmember stated, however, that it was often the crewmembers who were asking for briefings if they needed additional information.

   The timeline was sometimes less structured by the trainers than by the crewmembers themselves. The launch environment must be improved.

   The pre-launch quarantine was helpful since there was time that wasn't scheduled. It allowed time for physical and mental recovery.

   Post-Summit Questionnaire Responses

   Just taper off the final week.

   Yes. Schedule off time as part of prelaunch activities.

   Yes. No wimps allowed.

Psychological Support

Psychological Support

1. **An Apollo 12 debrief mentions a wish for recreational materials, such as books or music, during travel to and from the moon as there were stretches of time with little to do. Looking back, what effects would having access to such items meant for you? Is access to such items needed for the future missions?**

   "Don't remember having any time on my hands."

   It is very desirable to know what is going on in the world itself, news, sports, etc. Give me some way of getting this information in order to relax. "Send me the newspaper. Allow me to live there the way I live here. In the morning, I have a cup of coffee and read the newspaper."

   Maybe having electronic books would be good.

   Little things will frustrate you and hinder performance.

   Post-Summit Questionnaire Responses

   A plus
   We carried a tape machine and played music. Made living more normal.
   Yes

   a. **Regarding time alone after dropping others off on the lunar surface, what would make this more comfortable? Crewmembers reported that they liked the extra time, but wanted recreational activities when traveling to and from the Earth. In designing the CEV, what could be brought along to provide activities for the crew?**

   The CEV should be made as autonomous as possible.

   It is important to engage the mind on these trips. One crewmember reported that they did their own navigation and this gave them something to do. There are opportunities to look out the window. One crew used the x-ray spectrometer to take a picture of something that turned out to be a black hole.

   One crewmember stated that he wouldn't change a thing, since he had no problems passing the time. He enjoyed the time off and there are always housekeeping activities in the command module that need to be done.

   Post-Summit Questionnaire Responses

   Talk it over with crew. Some might like to play chess with opponents on Earth. I was very comfortable. Had a heavy workload and enjoyed the time.

   Yes

2. **During the debriefs the lunar missions CMPs offered candid insight into the isolation and boredom they faced after the CDRJ LMP left for the moon until their return. What steps would you offer to ameliorate these concerns for future lunar crews?**

Post-Summit Questionnaire Responses

I never felt isolated or bored. Obviously an individual matter.

XX. in the A-XX CM was 100% busy the whole time. If you know the moon, there should be plenty of experiments to do while going around up there.

Teddy bears

I was okay. Good to get rid of those 2 guys for awhile.

Would not worry about this -Have them take music and books and books on tape or CDs.

I never felt isolated nor bored. Getting rid of XXXX & XX for 42 hours was great - but still glad to see them come back! ! You had to be there.

I thought that the solo time was really precious. In fact. routine operational chores and flight plan maintenance was a nuisance. To get around this, we had Hank Hartsfield (CSM Capcom) run the flight plan when we had AOS so I could look out the window and contemplate what there was to observe. I'd resume flight plan responsibility on the back side. Thanks to some superb geology training, you could see an awful lot and test various hypotheses. And I didn't have to listen to country and western music!

Crew Scheduling and Task Loading

Crew Scheduling and Task Loading

1. **In designing future mission scenarios, what are your recommendations for optimizing operational success and crew health for each of the mission durations (including task loading, task timelines with recovery, conditioning to prepare for tasks and off-nominal events, etc.)?**

Post-Summit Questionnaire Responses

Practice, practice on the surface in suits where the tasks are defined and duplicated just like on the moon.

Allow time for all activities such as eating, resting, exercise, experiments, etc. We were preoccupied with the science.

Subject is far reaching and requires a great deal of discussion -Different positions have different responsibilities, i.e., CDR, CMP, LMP, Payload Spec, Mission Spec, EVA, etc. all different stressors.

2. **Were there any additional stressors, unique to Apollo and lunar surface vs. LEO? Are there any other Apollo/Moon unique factors to consider with regard to psychological preparation, support and scheduling?**

A person should be left to figure it out themselves. You prepare yourself. You were probably mentally ready when you were selected. Once you volunteer, those decisions are gone and you are ready to go.

After Apollo 1 or 13 we all could have left but no one did. As far as any programs, if you need a program you have the wrong people.

Getting everything done in the time you had to get it done was the highest stressor. Time is the greatest asset and enemy. You never have enough of it.

You get to the point where you have to perform and the biggest fear was screwing up and making the wrong decisions. "Thou shalt not screw up, first commandment."

Post-Summit Questionnaire Responses

Yes

   a. **What are the merits and demerits of the two weeks in quarantine postflight?**

There is disagreement about postflight quarantine. Some believe there is no possibility of anything surviving in a lunar surface environment that could be brought back and be dangerous to human beings. Others believe the postflight quarantine was justified because there may be unknowns. There was a question about why 21 days was the chosen period. Microbiologists advised that 21 days was about the maximum incubation period for any epidemics the world had seen. At the time, they didn't know about AIDS and other long-duration microorganisms that don't show up for a long time.

There was agreement that the quarantine allowed for postflight briefings and other activities to take place in a more tranquil environment without outside distractions.

Preflight quarantine is very valuable. From an operational point of view, it removed a large number of distractions from the last three weeks of preparations and the crews were much more rested.

Post-Summit Questionnaire Responses

Reduce the party load, although not critical.

Yes. Leprosy -21 days arbitrary (edited response)

APPENDIX C
APOLLO MEDICAL OPERATIONS PROJECT SUMMARY OF RECOMMENDATIONS EXCEL SPREADSHEET

Apollo Medical Operations Project Recommendations

	EMU/EVA SUIT	STATUS
1	Gloves should be custom designed for each crewmember that incorporate mechanical closure for gripping	Already in practice for flight gloves
2	Look into a wrist seal and depressurized glove	Will consider with counter pressure suit concept
3	Robotic power-assisted glove for repetitive tasks	Will consider in design for planetary suit configuration
4	Glove liners should be worn	Already in practice, to be continued in Cx D&C
5	Reduce the mass of the suit by a factor of two	Suit mass trades being evaluated by EPSP
6	Increase general mobility by a factor of four, primarily at the knee joint	Suit mobility requirements being defined by EPSP
7	Lower suit Center of Gravity	C.G. trades being evaluated by EPSP
8	Improve peripheral vision by adding neck ring (movable joint)	Requirement in Design & Construction document
9	Develop a reliable Heads Up Display that shows consumables information, limited biomedical data, and navigation on demand	Display requirement in HSIR for planetary suit.
10	The lunar boot functioned well and does not need to be improved.	Boot requirements in D&C
11	The drink bag should have capability to contain a high energy liquid in addition to plain water	Requirement in HSIR for planetary suit
12	Develop a better in-suit Urine Collection Device (UCD) that will work in 1/6 g	Requirement in HSIR, spec's for MAG will include improved interface.
13	The suit should be a low pressure (3.50 psia), single gas system	Requirement in HSIR- variable pressure suit 3.5-8.0 psi; 100% O2
14	Protect the suit zipper function	Consider in D&C specs
15	Develop a system that prevents helmet fogging during heavy exertion	Consider Helmet ventilation specified in D&C to prevent fogging
16	Use a self-sealing pressure garment within the suit for puncture	Consider HSIR requirement for DCS risk reduction Materials selection in D&C

Apollo Medical Operations Project Recommendations

	LUNAR SURFACE OPERATIONS	STATUS
17	Schedule crews for two Lunar EVA days on and one day for maintenance, alternating crews throughout the week	LAT and LAT defining architecture; to be placed in Ops Con document
18	The hatch and ingress corridor should be sized appropriately for an inflated I/6g pressure suit	Requirement for minimal hatch size in HSIR
19	An airlock may make ingress/egress easier and will also be a good idea from a dust control standpoint	Requirement for Airlock in EARD and CARD
20	Surface activities can begin once operationally feasible	Ops Con includes surface tasks for crew during landing day
21	There is no special training needed for 1/6 g EVA's other than a familiarization session.	Lunar Crew Training Plan
22	Limit navigation into craters to < 20 - 26º slope	Ops Con; will need a Flight Rule
23	Rover activities: CDR, LMP at risk for injury if not restrained	Consider for Rover requirements document; Medical contingency Ops
24	Risk for injury; Falling from a height; ladder, rim of a crater	Need Flight Rule; Medical contingency Ops Con
25	Ladder rung height and width on the Lunar Module (LM) were good but the glove did not allow adequate grip for safety	Revised handhold requirements in HSIR
26	Ensure adequate water and food are available before and during lunar EVA	Requirement in HSIR
27	Lunar EVA should be performed as one continuous event	Ops Con
28	Plan the operations on the surface so that you protect the crews from themselves	Will need Ground and Flight Rules to limit
29	With extended ops on the moon, establish all the experiments in the first week.	Will need Ground Rules and put Expedition planning guidelines
30	The Rover should have the ability to recharge the suit	Consider for Rover requirements document
31	Crews requested that an automatic position determination device be available to aid navigation on the lunar surface	Consider for EVA system requirements document
32	A robot should perform routine, systematic, repetitive, menial tasks (may help prevent repetitive use injuries).	Consider for EVA system requirements document
33	Allow adequate time to practice mission activities in a variety of environments including analogs that allow preparation for off-nominal events	Planetary exploration Analog WS to be held in March,
34	Allow adequate time in the schedule for all activities	Need GRnC entry for this

Apollo Medical Operations Project Recommendations

	IN-FLIGHT ILLNESS	STATUS
35	Lower back pain should be treated with aggressive pre-mission and in-flight core strengthening program	Cx MORD
36	Therapy to relieve muscle soreness, primarily in the forearms, must be available (improved glove design may assist this)	Cx Medical Kit contents definition
37	Constipation: improve the waste management collection system	Requirement for waste management in HSIR
38	Screen for CAD prior to selection for lunar missions	Medical standards now required for long duration flight
39	A physician crewmember would increase the comfort level among the crewmembers and can be cross-trained to do other activities	Consider development of Crew selection guidelines
40	Adequate preventive measures and treatment for diarrhea must be available	Cx Medical Kit contents definition
	MEDICATION/MEDICAL KITS	**STATUS**
41	A card in the medical kit to inform the crew of the medication duration, indication, and interaction with other meds is needed	Cx Medical Kit contents definition
42	Add non-sedating antihistamines for allergy symptoms due to lunar dust exposure	Cx Medical Kit contents definition
43	Saline eye drops need to be available in large quantities (however an eyewash will be available as part of the environmental health kit)	Cx Medical Kit contents definition
44	Provide items that are needed in daily life, e.g. nail clippers, lotions, band-aids, etc. (individual hygiene kit will be available)	Flight Crew Equipment contents definition, currently included in long duration flight crew kits for ISS
45	Sufficient analgesia to treat headaches	Cx Medical Kit contents definition
46	Sleep medication must promote restful sleep but not be too sedating	Cx Medical Kit contents definition

Apollo Medical Operations Project Recommendations

	ENVIRONMENTAL IMPACTS	STATUS
47	Consider adapting the Skylab waste management system into the new vehicles	Requirement for waste management in HSIR
48	The sleep restraint system on the Apollo CM worked well and should be incorporated into the new vehicle design (Sleeping bag needs to be large enough for crewmembers to get both knees to their chest)	Requirement for sleep in HSIR
49	Drinking water should be available during sleep periods	Requirement for potable availability at all times in HSIR
50	Lunar Surface Ascent Module (LSAM) windows should be designed to see only what is necessary for landing and/or rendezvous with IR protection	Consider for LSAM req's document
51	Thermal protective clothing or equipment should be available on board	Flight Crew Equipment contents definition
52	Minimize noise but do not eliminate it (earplugs are an adequate countermeasure for noise)	Acoustics requirements in HSIR
53	CO2 monitoring device needs to be robust and reliable	Requirement in HSIR
54	A food warmer is desirable	Requirement in HSIR
55	Astronaut participation in the design and development phases of the new vehicles is essential	Currently in practice for Cx for each vehicle and requirements definition.
56	Radio Frequency ID tags should be considered for stowage items	Consider for CxP level 4 and 5 documents- design solutions for stowage tracking
57	Hot water capability for hygiene, beverage and food preparation is essential	Requirement in HSIR
58	Apollo bag aperture and capacity needs to be larger and easier to apply in microgravity	Contingency waste collection requirement in HSIR- details will be defined in Cx document
59	Create a device that would allow crewmembers to assume a squatting position in microgravity	Requirement in HSIR
60	Do not design the galley and waste management areas together	Requirement for separation in HSIR

	RADIATION	STATUS
61	Vehicle should have an active radiation detector with an automated audible alarm that sounds when the dose rate exceeds a predetermined level	Requirement in HSIR
62	A Personal Radiation Dosimeter is a requirement for all crewmembers and should be designed into suit garments	Requirement in HSIR; Need also in EVA system and suit requirements document
63	The rover should be equipped with a radiation shield	Consider for rover requirements document
64	Radiation protectants should be made available to the crewmembers	Cx Medical Kit contents definition - research ongoing but poorly funded
65	Create a trench with shovels or explosives to protect the crew short term in the event of a Solar Particle Event	Consider for radiation protection Con Ops; perhaps use alternate strategies

Apollo Medical Operations Project Recommendations

	BEHAVIORAL HEALTH AND PERFORMANCE	STATUS
66	Preflight quarantine is very valuable that allows time for sim time, exercise and rest.	Need to be built into GRnC and crew training plan; CxMORD
67	Recreational activities need to be made available for crews during Trans Lunar Coast and Trans Earth Coast. CMP during lunar surface operations.	BHP Req's in HSIR
68	Lunar crews should have one day a week for "rest" (freedom to select their activity)	Need GRnC entry for this
69	Mental and physical rest plans should be introduced into extended moon stays to allow adequate rest between lunar EVA	Need GRnC entry for this
70	Mission focus should be project-oriented and not timelined	Need to capture this philosophy in Ops Con for lunar outpost missions
71	Provide adequate capabilities for sleeping on the lunar surface	Sleep requirements in HSIR
72	If a crewmember dies during the mission you cut him/her loose	Need to develop Med Code 0 Ops Con and Cx MORD
73	In planning crew size/makeup, the authority structure is much more significant than crew size	Consider development of Crew selection guideline
74	The pre-flight training schedule should allow for crews to concentrate on issues that will be used for the nominal mission	Consider for crew training plan
75	An eight hour/day sleep period must be protected in the daily schedule and must not be compromised	Need GRnC entry for this
76	Crew sleep periods should be scheduled at the same time	Need GRnC entry for this
77	Use of sleeping medication should be encouraged where appropriate	Need to Cx MORD
78	Countermeasures to combat mental fatigue are necessary throughout the mission	Cx Medical kit definition
79	Education and psychological services should be available to the crewmember's families	BHP Requirements in HSIR

Apollo Medical Operations Project Recommendations

	EXERCISE	
80	Loosen the pre-mission timeline to allow adequate time for pre-flight conditioning program	Need to be built into GRnC and crew training plan; CxMORD
81	A more robust (and lightweight) piece of in-flight exercise equipment is needed than the Apollo Exer-Genie	Requirement in HSIR; Need h/w spec definition at level 4 and 5
82	The flight surgeon/mission planners should not plan specific exercise prescriptions for short duration (< 14 days) mission	Not consistent with SA position (we say < 8 days).; HSIR req's for exercise for all missions > 8 days.
83	Exercise is not necessary on short trips (14 days or less) [from a fitness standpoint], however crews demanded that the capability be available and varied as much as possible for crew "rest and relaxation" in all phases of the mission	HSIR requirement to begin exercise as soon as practical
84	Develop a better pre-flight and in-flight forearm muscle conditioning program for lunar crewmembers in addition to the core stabilization program	CxMORD; ASCR pre-flight prep
85	New vehicle design should allow a variety of different exercise capabilities (hardware vs. cabin structure)	Requirement in HSIR; need outpost exercise requirements added
86	New exercise device should be reliable, simple and not develop excessive heat in use	Requirement in HSIR; Need h/w spec definition at level 4 and 5
	FOOD/NUTRITION	**STATUS**
87	Mission activity (e.g., coast, rendezvous, lunar orbit, lunar ops) will dictate what type and how much food will be consumed. High Activity: wet packages, bite-sized snacks, canned foods. Low Activity: spoon bowls, dry juice or meals (rehydratable) requiring mixing, etc.	Nutrition requirements in HSIR; CxMORD; Need food system requirements at level 4 and 5
88	Plain water in large quantities needs to be available for lunar EVA	Requirement in HSIR
89	Optimize diet and food intake for overall performance during long duration missions	Requirement in HSIR
90	An in-suit non-caffeinated solid or liquid carbohydrate food source for lunar EVA would be helpful.	Requirement in HSIR
91	Design adequate space an useful area in the new vehicles to store food packs during meals	Stowage requirement in HSIR
92	Spicy and salty foods are preferred items in the menu	Food system requirement at level 4 and 5
93	Allow adequate time in the daily schedule for meals	Need GRnC entry for this
94	Determine how different environmental factors (e.g. O2 concentration, cabin pressure) effect food flavor	Need research topic for HRP

Apollo Medical Operations Project Recommendations

	LAUNCH, LANDING, AND RECOVERY OPS	STATUS
95	Provide adequate cooling capabilities for the crew on landing to mitigate the hot cabin contribution to crewmember sea sickness	Cabin environment req in HSIR; 36 hr post-landing tiger team working details of ECLSS, suit, etc. need CR to CEV SRD
96	Ground landings discouraged	Land vs. water tiger team weighing trades
97	Apollo seat configuration for water landings were adequate: the restraint system needs to include loose equipment items	Seat req's in HSIR; CEV SRD (previously in crew cockpit document)
98	Medication for motion sickness and fatigue will be available prior to re-entry	CxMORD; Medical Ops Con
99	Hatch should open outward and seal with pressure	Hatch requirements in HSIR
100	Sea state should be limited to < 6-8 foot swells if recovery is to be delayed	CEV SRD defines sea state for vehicle; Ground Ops con defines recovery strategy
101	Have food and plain water within reach of buckled crewmembers for delayed recovery	Need to add requirement to HSIR and CEV SRD
102	Apollo Command Module hatch location and size was adequate for egress	Hatch requirements in HSIR
103	All control panels and switches should be within reach of crewmembers during launch and landing	Cockpit requirements in HSIR; CEV SRD and Crew Cockpit document
104	Training for pad abort was adequate and should be continued	Need to include in crew training plan
105	Crew surgeon should be on the recovery vessel and not the helicopter	Ops Con

	FLIGHT SURGEON-CREW INTERACTION	STATUS
106	Crew encouraged FS to "act as more of an advocate of the crew" than treat them as an experiment	Currently in practice
107	The collaboration established between the current flight surgeons and Apollo crewmembers should continue and be an example to future generations	Roger and concur

APPENDIX D
APOLLO MEDICAL KITS FROM *BIOMEDICAL RESULTS OF APOLLO*[5]

Apollo Medical Kits[1]

	Apollo 7	Apollo 8	Apollo 9	Apollo 10	Apollo 11	Apollo 12	Apollo 13	Apollo 14	Apollo 15	Apollo 16	Apollo 17
Apollo Medical Accessories Kit											
Constant Wear Garment Harness Plug									3	3	3
ECG Sponge Packages									14	14	14
Electrode Bag	1	1	1	1	1	1	1	1	1	1	1
Electrode Attachment Assembly	12	12	12	12	20	20	20	20	100	100	100
Micropore Disc	12	12	12	12	20	20	20	20	50	50	50
Sternal Harness	1	1	1	1	3	3	3	3	3	3	3
Axillary Harness	1	1	1	1	1	1	1	1	1	1	1
Electrode Paste	1	1	1	1	1	1	1	1	1	1	1
Oral Thermometer	1	1	1	1	1	1	1	1	1	1	1
pH Paper	1	1	1	1	1	1	1	1	1	None	None
Urine Collection and Transfer Assembly Roll-On Cuffs	3	3	6	6	6	6	6	6	6	6	6
Lunar Module Medical Kit[2]											
Rucksack	---	---	---	---	---	1					
Stimulant Pills (Dexedrine)	---	---	---	---	---	4					
Pain Pills (Darvon)	---	---	---	---	---	4					
Decongestant Pills (Actifed)	---	---	---	---	---	8					
Diarrhea Pills (Lomoid)	---	---	---	---	---	12					
Aspirin	---	---	---	---	---	12					
Band-Aids	---	---	---	---	---	6					
Compress Bandages	---	---	---	---	---	2					
Eye Drops (Methylcellulose)	---	---	---	---	---	1					
Antibiotic Ointment (Neosporin)	---	---	---	---	---	1					
Sleeping Pills (Seconal)	---	---	---	---	---	6					
Anesthetic Eye Drops	---	---	---	---	---	1					
Nose Drops (Afrin)	---	---	---	---	---	1					
Urin Collection and Transfer Assembly Roll-On Cuffs	---	---	---	---	---	6					
Pronestyl	---	---	---	---	---	12					
Injectable Drug Kit											
Injectable Drug Kit Rucksack	---	---	---	---	---	1					
Lidocaine (cardiac)	---	---	---	---	---	8					
Atropine (cardiac)	---	---	---	---	---	4					
Demerol (pain)	---	---	---	---	---	2					

Apollo Medical Kits[1]

	Apollo 7	Apollo 8	Apollo 9	Apollo 10	Apollo 11	Apollo 12	Apollo 13	Apollo 14	Apollo 15	Apollo 16	Apollo 17
Command Module Medical Kit											
Methylcellulose eye drops (0.25%)	2/1	2/2	2/0	2/0	2/0	2/0	2/0	2/0	1/0	2/0	1/0
Tetrahydrozoline HC1 (Visine)	---	---	---	---	---	---	---	---	---	---	1/0
Compress - bandage	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0
Band-Aids	12/2	12/2	12/2	12/2	12/2	12/2	12/2	12/2	12/2	12/2	12/2
Antibiotic ointment	1/1	1/0	1/0	1/0	1/0	2/0	2/0	2/0	2/0	2/1	2/1
Skin cream	1/0	1/1	1/1	1/0	1/0	1/0	1/0	1/0	1/0	1/1	1/0
Demerol injectors (90 mg)	3/0	3/0	3/0	3/0	3/0	3/0	3/0	3/0	3/0	---	---
Marezine injectors	3/0	3/0	3/0	3/0	3/0	3/0	3/0	3/0	3/0	---	---
Marezine tablets (50 mg)	24/3	24/1	24/4	12/0	---	---	---	---	---	---	---
Dexedrine tablets (5 mg)	12/1	12/0	12/0	12/0	12/0	12/0	12/1	12/0	12/0	12/0	12/0
Darvon compound capsules (60 mg)	12/2	18/0	18/0	18/0	18/0	18/0	12/1	18/0	18/0	18/0	18/0
Actifed tablets (60 mg)	24/24	60/0	60/12	60/2	60/0	60/18	60/0	60/0	60/0	60/0	60/1
Lomotil tablets	24/8	24/3	24/1	24/13	24/2	24/0	24/1	24/0	24/0	24/0	48/5
Nasal emollient	1/0	2/1	2/1	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0
Aspirin tablets (5 gr)	72/48	72/8	72/2	72/16	72/unk	72/6	72/30	72/0	72/0	72/0	72/0
Tetracycline (250 mg)	24/0	24/0	24/0	15/0	---	---	---	---	60/0	60/0	60/0
Ampicillin	---	60/0	60/0	60/0	60/0	60/0	60/0	60/0	60/0	60/0	60/0
Seconal capsules (100 mg)	---	21/1	21/10	21/0	21/0	21/6	21/0	---	21/0	21/3	21/16
Seconal capsules (50 mg)	---	12/7	---	---	---	---	---	---	---	---	---
Nose Drops (Afrin)	---	3/0	3/1	3/0	3/0	3/1	3/0	3/1	3/0	3/0	3/3
Benadryl (50 mg)	---	8/0	---	---	---	---	---	---	---	---	---
Tylenol (325 mg)	---	14/7	---	---	---	---	---	---	---	---	---
Bacitracin eye ointment	---	---	1/0	---	---	---	---	---	---	---	---
Scopolamine (0.3 mg) - Dexedrine (5 mg Capsules)	---	---	---	---	12/6	12/0	12/2	12/0	12/0	12/0	12/1
Mylicon tablets	---	---	---	---	40/0	40/0	40/0	40/0	40/0	40/0	40/0
Opthaine	---	---	---	---	---	---	1/0	1/0	1/0	1/0	1/0
Multi-Vitamins	---	---	---	---	---	---	---	20/0	---	---	---
Auxiliary Medications											
Pronestyl	---	---	---	---	---	---	---	---	---	80/0	80/0
Lidocaine (cardiac)	---	---	---	---	---	---	---	---	---	12/0	12/0
Atropine (cardiac)	---	---	---	---	---	---	---	---	---	12/0	12/0
Demerol (pain)	---	---	---	---	---	---	---	---	---	6/0	6/0

(1) Biomedical Results of Apollo. SP-368, P.33

(2) Typical quantities and items; no standard lunar module medical kit. Kit adequacy reviewed after each mission. Appropriate modifications made for future missions

APPENDIX E
CORRESPONDENCE

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
2101 NASA Road 1
Houston, Texas 77058-3696

May 9, 2006

Reply to Attn. of: SD-06-029

Dear

The Space Medicine Division at NASA/Johnson Space Center is currently developing the medical requirements for the Crew Exploration Vehicle (CEV), Lunar Surface Ascent Module (LSAM), Lunar Habitat, and Advanced EVA suits.

In order for Medical Operations to write requirements for the new systems and hardware, a thorough review of the Apollo mission documents was conducted. This review identified areas that need further clarification before beginning development of future crew health and safety systems.

We request your attendance at a face-to-face meeting on June 7-9, 2006 in Houston. Our main goal is to elucidate any insight you may have into opportunities for improvement and to provide your ideas for future missions emphasizing the steps necessary to ensure crew health and safety based on your experience. The results of your efforts will be evident in the creation or modification of requirements for the exploration vehicles, suits, and mission activities, as well as flight surgeon support of exploration crews.

The first two days of this meeting will be private and limited to current flight surgeons, Apollo crewmembers, and administrative support personnel. The third day will be open to other parties interested in participating in the discussions. Please feel free to suggest additional invitees (e.g. members of the research community, current astronauts, Apollo flight surgeons, flight directors or engineering staff) that you feel would contribute to the third day.

Please confirm your desire to attend this meeting by **May 26, 2006.** Point of contact for the event and travel funding information is Dr. Rick Scheuring, (281) 743-1510, richard.a.scheuring@nasa.gov.

Sincerely,

James M. Duncan, MD
Chief, Space Medicine
NASA/Johnson Space Center

wyle laboratories

May 5, 2006

Dear Mr.

I certainly hope you accept our invitation to this June meeting as it will be very exciting to hear from you as to how we can create the best program for crew health and safety.

To best facilitate the meeting and maximize your time with us, we will have pertinent issues from the Apollo documentation researched and ready for discussion. For example, a couple of issues from the Apollo16 documents include:

1) Crew comment – Urine volume measurements were difficult at best and quite time consuming for the crew to perform. The procedures for the urine dump system were not well thought out.
   Our questions – A portion of body fluid is lost through insensible means (respiration, perspiration, etc.) not easily measured. Obtaining daily fluid input/output is an important indicator of hydration status, but not perfect.
   What system of maintaining accurate records of input/output would the crew recommend, given all the trouble they had with the water and waste management systems?
2) Crew comments – During the three lunar EVA's, the crew often worked harder during "rest" periods (as evidenced by heart rate data) than during work periods. However, the crew did not feel this level of physical activity pushed them to their exercise capacity limits.
   Our questions – The three lunar EVA's totaled 20 hours and 17 minutes. Although you did not feel physically challenged during your lunar EVA's, can you offer any insights how you might have felt carrying out this surface activity timeline over the course of 7-14 days? How do you feel the pre-flight EVA training program prepared you for lunar EVA? What would you do differently in your training for these longer surface sorties?

These are a few examples of the many questions that only the Apollo crew members can answer which is why this meeting is very important to future missions. We've discussed this project with LG Stafford, Dr. Schmitt, and Capt. Cernan, who are in agreement with our primary objectives: to make sure those issues encountered during the Apollo missions are brought forth and discussed to optimize crew health and performance and prevent "reinventing the wheel."

During your visit, we are including a tour of several mock-ups of the exploration vehicles including the CEV and lunar habitat. Also, if you prefer, we can coordinate your visit with the

Life Sciences Systems and Services 1290 Hercules Drive, Houston, TX 77058-2769 Tel: 281.212.1200 FAX: 281.212.1210

Longitudinal Study group and the Flight Medicine Clinic to complete your annual physical exam during the same trip.

Please call me at 281-461-2774, e-mail at Richard.a.scheuring@nasa.gov with your intentions or if you have any questions. Thank you for considering this invitation and we look forward to working with you.

Sincerely,

Richard A. Scheuring, D.O., M.S.
Apollo Summit-Project Manager
Advanced Projects/Flight Surgeon

APPENDIX F
MEETING AGENDA

National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
2101 NASA Road 1
Houston, Texas 77058-3696

Reply to Attn of: SD-06-261

October 03, 2006

Dear

Enclosed is the CD containing the Apollo Medical Operations summit material as promised:

- Agenda
- NASA/Wyle Laboratories personnel list
- Meeting presentations in PowerPoint
- Final panel questions and answers
- Excel spreadsheet with the participating post-summit responses
- Articles from the EVA Summit 1994, Medical Legacy of Apollo, and Space Adaptation Syndrome
- Biomedical results of Apollo
- NASA photos from Days 1-3

To date we have compiled 104 recommendations from your participation to improve current requirements or develop new standards for the exploration vehicles, suits, protocols and responses to contingencies. The recommendations you provided during the summit and subsequent communications has had a significant impact on the medical operations exploration architecture. For example, requirements for waste management, environmental systems, and suit design have been developed or modified based on your input. We gained insight into the risk factors to consider for falls on the lunar surface through our discussions. This information will enable medical operations to provide an evidence-based approach to developing hardware and protocols for lunar surface operations.

One recommendation that was brought forth during the meeting was to continue the dialogue on exploration issues between the flight surgeons and Apollo crewmembers. We look forward to this collaboration and appreciate the investment of your time and experience in this effort.

Sincerely,

J.D. Polk, D.O., MS, FACOEP
Manager, NASA Medical Operations

Rick Scheuring, D.O., MS, FAAFP
Project Manager, Apollo Medical
Operations Summit
UTMB/Wyle Laboratories

Apollo Constellation
Medical Operations Summit
June 7-8, 2006

Space Center Houston-Club Conference Room

Wednesday Morning, 7 June 2006

7:30	**Continental Breakfast**
8:00	**Opening Remarks - Mr. Mike Coats**
8:15	**Welcome and Introductions** – JD Polk, DO • Safety procedures • Review Agenda • Rules of Engagement
8:45	**Apollo Missions Medical Summary:** **Impacts on Crew Health & Performance** – Rick Scheuring, DO Review of Apollo data sources
9:30	***Break***
9:45	**Constellation mission design and architecture** – Jeff Jones, MD
11:15	**Exploration Medical Operations CONOPS** – JD Polk, DO
12:00	***Lunch***

Wednesday Afternoon, 7 June 2006

13:00	**Breakout session introduction - Joe Kerwin, MD**		
TIME	**SESSION**	**GROUP A**	**GROUP B**
13:10	1	EVA Suit Crew Medical & Safety Issues	
14:30	***Break***		
14:45	2	Lunar Surface Ops	
16:30	**Summary** – JD Polk, DO		
17:00	*End of Day 1*		

Apollo Constellation
Medical Operations Summit
June 7-8, 2006

Space Center Houston-Club Conference Room

Thursday Morning, 8 June 2006

7:30	**Continental Breakfast**		
8:00	**Overview of Day 2 -** JD Polk, DO		
TIME	**SESSION**	**GROUP A**	**GROUP B**
8:15	3a	Environmental Impacts	Illness, Med Kits, Bioinstrumentation
9:10	3b	Illness, Med Kits, Bioinstrumentation	Environmental Impacts
10:00	*Break*		
10:10	4a	Exercise/Food/Nutrition	Crew Schedule
11:00	4b	Crew Schedule	Exercise/Food/Nutrition
11:45	*Lunch*		

Thursday Afternoon, 8 June 2006

TIME	SESSION	GROUP A	GROUP B
12:30	5a	Launch/Recovery Ops	Performance
13:25	5b	Performance	Launch/Recovery Ops
14:15	*Break*		
14:25	4a	Flight Surgeon/Crew Interaction	Free Association
15:00	4b	Free Association	Flight Surgeon/Crew Interaction
15:30	Summary of Day 2 – JD Polk		
16:00	BLDG 9	CEV/POGO	EVA Walk-back Tour at B9
17:00	*End of day 2*		

Apollo Constellation
Medical Operations Summit
June 7-8, 2006

Space Center Houston-Club Conference Room

Friday, 9 June 2006

7:30	**Continental Breakfast**
8:00	**Opening Remarks -** Drs. Rich Williams, Joseph Kerwin, Harrison Schmitt
8:30	**Welcome and Introductions –** JD Polk, DO • **Safety procedures** • **Review Agenda** • **Rules of Engagement**
8:45	**Flight surgeon view on medical issues and support from Apollo –** JD Polk, DO • Summarize knowledge gaps for open sessions
9:30	***Break***
9:45	**Constellation mission design and architecture –** Jeff Jones, MD
10:30	**Open sessions –** JD Polk, DO • Summary of Day 1 & 2 Recommendations – Rick Scheuring, DO **Session 1** • Apollo crewmembers address invited guest questions 1 EVA Suit Crew Medical & Safety Issues 2 Lunar surface operations 3 Crew work/rest schedules
12:00	***Lunch***
13:00	**Session 2** 4 Environmental Impacts 5 Bioinstrumentation/Medical Kits 6 Food/nutrition
14:45	***Break***
15:00	**Session 3** 7 Exercise 8 Launch/Recovery operations

APPENDIX G
PERSONAL COMMUNICATIONS

Richard,

Nothing is based on my input since I don't recall ever making one on the CEV. I was supporting Northrop Grumman on their proposal effort and felt it might be a conflict of interest. You also sent me one for inputs on the Landing craft crew accommodations, relative lunar surface stay. I did not respond on that one either as I did not land and have the experience to relate.

Now that the competition is over and the CEV overweight, I will look at your email and provide my thoughts.

Regards,
Fred Haise

From: tkmattingly
Subject: Comments on your Apollo Medical Briefing charts

Rick,

Thanks for sharing your results. A couple of thoughts from reading the presentation follow.

1. Lots of good ideas but we have to remember that spaceflight will always be constrained by mass, volume and power. Suggest that while you have everyone's attention you might try to prioritize these desires. Recommend use of the pair-wise comparison technique to help eliminate unrecognized internal pressure. If you're not familiar with the technique, it involves making a list of all options and then having each evaluator compare the importance of each possible pair. This requires establishing a single objective, such as, "if I was returning to the moon and could have only one improvement, which of each pair would I prefer having?" Then, start with number one on the list and test it against each other suggestion, one at a time. Then you rank order the ideas according to the number of these pair-wise votes. That is #1 vs. #2, #1 vs #3, etc. then #2 vs. #3 ..... You and your evaluators may be surprised at the results. Armed with this info, you can make better choices when the cost and schedule crunch time arrives.
2. I think I mention that the taste of food in Apollo was lousy but some of the same foods tasted good in shuttle. I attributed this to the lack of a diluent gas but may be due to some other aspect of the cabin environment such as total pressure.
3. The only discomfort (nuisance) I encountered in space flight was the periodic episodes of nasal congestion. During Apollo, it would come and go. During shuttle, I noticed that 30 seconds on the treadmill would clear the sinuses for hours. I tried it on others and they had the same reaction. I believe this is due to the redistribution of fluid within the body during micro-g. Seems consistent with the observed swelling of our faces. Also wonder if this might be applicable to headaches. Can't tell from experience because I was one of those fortunate enough to have avoided such episodes.
4. Lots of comment on impotence of Exer-genie. I didn't find it particularly satisfying or useful but found the Shuttle treadmill to be a magic device. I think the body as a whole responds far more to the large mass muscles in the legs than to the arms.
5. You observed that while many of the lunar crews experienced trauma to parts of the hands during lunar surface EVA, this had not been an issue in training. It occurs to me that we all had our custom flight suits made as small as possible to maximize mobility. What we didn't account for was the fact that our bodies stretch when gravity is removed. Some folks had a hard time zipping up on orbit. We made some measurements during early STS flights that showed how much our height extended on orbit. Don't think we ever thought about measuring changes in arm length but it would seem logical. If we had tight suits and our bodies extended, even in 1/6th g, this could account for your observation.
6. I think I mentioned that the biggest contributor to glove forces was the thermal insulation layers. If you're thinking of augmenting the gloves with mechanical aids, you might consider using a pressure sensitive sensor on the interior of the glove and sending this signal back to a mechanical aid on the back of the hand. It should be sized to offset only the glove

(finger) bending loads, not create a bionic hand. It should work in both directions and have the ability to be disabled without adding additional loads.

Good show. The time is right to start think about these things again.

TK

From: Harrison Schmitt
To: Scheuring, Richard A. (JSC-SD)
Subject: Sleep in Apollo

See CAPS embedded below. Just remember that operations will start out conservative and then get more realistic as experience is gained.

Harrison

-----Original Message-----
From: Scheuring, Richard A. (JSC-SD)
Harrison H. Schmitt

Dr. Schmitt-

The Apollo recommendations are getting a lot of attention on the Constellation side of things these days. That being said, a question has come up regarding sleep (below), the procedure for a cabin depress on return from the moon, and the land vs. water landing issue. The sleep issue is primarily concerned with sleep on the lunar surface. I remember the lunar crews stating that lack of sleep was multifactorial, but environmental issues, such as inability to adequately block sunlight from the windows, laud background noise, and a cold floor were some of the more pressing issues. The hammock seemed to work okay from what I remember for the short stays, but how well would they work for longer duration missions?

FROM MY PERSPECTIVE, APOLLO 17 BENEFITED FROM ALL THE EXPERIENCE AND MISTAKES OF PREVIOUS MISSIONS, AT LEAST I WENT TO A LOT OF EFFORT TO MAKE THIS THE CASE. SUNLIGHT (WE PUT SHADES ON THE WINDOWS), NOISE (IT WAS COMFORTING TO HEAR THINGS DOING WHAT THEY SHOULD DO AND IF THEY HAD NOT, IT WOULD HAVE BEEN "A WAKE-UP CALL"), HAMMOCKS (VERY COMFORTABLE IN ONE-SIXTH G) WERE NOT PROBLEMS AND CERTAINLY WOULD BE OKAY FOR A WEEK. I AM NOT SURE CERNAN SLEPT AS WELL AS I DID (I WOKE BRIEFLY EVERY TWO HOURS OR SO, I THINK), BUT YOU SHOULD ASK HIM IF NOT COVERED IN HIS BOOK. I THINK WE ALL SLEPT WELL IN THE CM - RON CERTAINLY DID! THEY COULD NOT WAKE HIM ONE MORNING WHEN HE WAS ON WATCH.

I CAN ONLY SPEAK FOR MYSELF, BUT I DID NOT FEEL SLEEP DEPRIVED BEFORE ANY LUNAR EVA. I LITERALLY FELT AS READY AFTER EACH SLEEP PERIOD AS I DID BEFORE THE FIRST EVA.

Currently, we are working out a 144 hour depress scenario where the cabin has vented to space over time and the leak cannot be found. Consequently the crews are in their suits for the ride home. Did you have any such procedures during Apollo? Lots of issues associated with this scenario and I would like some guidance on how you might have handled it.

I DON'T REMEMBER HOW APOLLO RULES STARTED OUT BUT APOLLO 17 AND MOST OTHER MISSIONS IF NOT ALL WERE OUT OF THE SUITS FOR THE RETURN, BUT DID HAVE PROCEDURES FOR EMERGENCIES. WE DID NOT WEAR THEM EVEN FOR ENTRY. I WOULD NOT LET THE ENGINEERS ASSUME THAT THE CREW WILL STAY IN THE SUITS FOR 144 HOURS! THE ORION MUST BE BETTER THAN THAT.

The recommendation from the summit was that the Apollo crews preferred a water landing over land. This is a hot topic because Constellation is opting for land at this point in time.

THIS IS A DESIGN ISSUE AND A DESIGN CONFIDENCE ISSUE. I WOULD PLAN A MISSION FOR WATER LANDING TO BUILD CONFIDENCE, MAYBE THAT "APOLLO 8" STYLE MISSION YOU ARE CONSIDERING.

The Apollo concern was off-nominal re-entry putting the spacecraft in downtown LA or some other populated area. Water landings allowed a much greater margin of error. However, the vehicle cannot be re-used and this seems to be one of the drivers for a land landing. Were there other concerns that made water preferable? Also, the outward opening hatch in the CM has raised a number of questions, but I think this recommendation came from the Apollo 204 experience.

YES. WHAT ARE THE QUESTIONS?

The draft of the completed paper is almost ready to send out. I am briefing the Constellation control board (CxCB) on Wednesday and fully expect to field questions related to these and other issues. Your time is greatly appreciated. Please call me (281.743.1510) if you would rather discuss this on the phone than email.

Thanks again,
Rick

Richard A. Scheuring, DO, MS
Constellation Medical Operations Specialist NASA-Johnson Space Center

From: N. Armstrong
To: Scheuring, Richard A.
Sleep in Apollo

Dear Dr. Scheuring,

I found your e-mail awaiting my return from a little time in Washington.

With regard to sleep issues, my Apollo procedures documents are in storage so I must depend on memory, which is not very good.

We did not have any sleeping facilities in the LM, which was marginally acceptable for the 3 day period. For anything longer than that, reasonable sleeping accommodations should be provided to assure that productive time could be assured during the working day. The problems we had: (1) light in the cockpit (2) pump noise (3) cold temperatures, and (4) inadequate sleeping facilities -- all seem to readily solvable.

I cannot comment on the hammock. We had only a improvised leg sling in the A-11 LM. The Command Module sleeping sacks seemed to work reasonably well.

We kept our pressure suits available for whenever they might be needed. I'm sure we had some kinds of procedures, but I can't remember any details without the check lists. Operating in pressurized suits is difficult and brings with it a substantial amount of risk: inadvertent switch or control operations, inability to reach controls, substantial difficulty in moving about the cabin, etc. For that reason, Gemini and Apollo crews pressed for a 'shirt-sleeve environment'. The pressure suit is mandatory for situations such as the one you postulate, but when not absolutely required it is genuinely disadvantageous.

The Mercury, Gemini, and Apollo launch trajectories were all over water. So the ability to safely land in water was required for any launch abort. The Soviet launch trajectories were principally over land. So the ability to land safely on the land was required for their launch aborts. Once providing the ability for the launch case, it made sense (with our extreme weight limitations) to use the same system for both.

I suspect Orion/Ares will also need to provide a launch abort ability for water landings. Whether there will be a substantial weight penalty for adding land landing ability, I do not know. I certainly understand the reluctance to accept the costs of water landings as a routine matter, so I could support a land landing if I were convinced that there was a very high probability of landing close to the intended destination.

These are just some random thoughts, so I provide them with some reluctance, but I am confident that you will consider them in the light of their incompleteness.

Sincerely,

Neil Armstrong

From: lovell13
To: Scheuring, Richard A.
Subject: Sleep in Apollo

Dear Mr. Scheuring:

In regards to your e-mail of April 9th -- in zero gravity sleep is not a problem. The body can be lightly restrained within a body bag. Body heat will form a blanket within the bag. If the noise level is low and once the person gets use to sleeping in a strange environment, there should be no problem.

In a gravity environment such as the lunar surface consideration has to be given to adequate space, cold surfaces, body pressure points and the noise level. From what I heard, these factors were marginal in the lunar module.

Water landings were preferred in Apollo for the following reasons:

1. The availability of large bodies of water to accommodate long landing foot pads dictated by high reentry velocity.
2. The consistency of the landing surface and the absence of uneven terrain and large obstacles.
3. The elimination of wings and therefore weight.
4. The ease to position the recovery force.
5. The necessity to plan to land in water in emergency since Apollo launched east from Cape Canaveral.

I hope this can be of help.

Captain Lovell

From: Harrison H. Schmitt
Subject: CM Life support back-up, etc.

Dr. Schmitt-

The CEV is approximately 5000 pounds overweight and the program is looking at hardware and systems that it can cut back to save weight. They want to go to zero or single fault tolerant systems on some of the hardware. Amazingly, redundant crew life support systems are on the chopping block, such as the oxygen tanks. Apparently, Apollo had a single oxygen surge tank (in the SM) that fed the single Command Module O2 system for entry. Other items include the toilet, proposed exercise equipment, food and water allotments, tool kit, window vs. windowless system, etc. Many of these items we discussed during the Apollo summit and developed recommendations for requirements per your input. We are going to have to go back and rejustify these items or lose the requirement…

Wow! Some of the Apollo manifest questions might be answered in the "Apollo Lunar Surface Journal" where there are a lot of references that might include tool kits, etc. Also, check with Joe Cosmo in crew systems. Someone there must have all the on-board printed data sets. I have some here, but it will take me some time to search them out. Let me know if you can't find what you need.

A couple of questions:

1. *We are requiring a redundant oxygen system for primary failures, such as MMOD hits, etc. in the CEV for entry. Loss of the primary O2 system is low but the back up in this life support equipment makes sense. Apparently, Apollo only had one tank in the CM, what was the rationale behind that, given the same hazards we will face with the CEV?*

Can you contact Aaron Cohen (CM project manager) through Texas A&M on this? Dick Kohrs worked for him and he is around. Aaron is ill, and I do not know his status. Sy Libergot (EECOM) would probably remember as well. My guess is that the Apollo system was simple enough that they decided that the risk of a loss was very small unless the cm was destroyed. Definitely try to find Sy.

2. *What kind of tools did you use for vehicle maintenance? What kind of maintenance issues came up in the vehicle requiring repair and is this something that we need to keep for the new vehicle?*

We never used any tools that I recall. We all used duct tape at some point. Gene and I used clamps. Spillage of water, food, waste were the only maintenance issues I recall. Was there a tool kit in the CM and or LM?

3. *We have a requirement for a single suit system. However, taking your input about the lack of mobility in the lunar suit, primarily at the waist, into consideration we are evaluating building a waist ring into the suit. However, this capability has the potential for injury in the event of a off-nominal landing. Therefore, a separate launch/entry suit*

and lunar surface suit are being considered. What are your thoughts about the mass/vol impact of a two-suit system versus the injury potential of a single suit system?

I guess I would stick with a single suit. We did not wear our suits for entry.

4. *Lastly, the hot water dispenser requirement is in the parking lot, so to speak. We fought hard, based on your input, to develop and keep this requirement. This has been a tough battle, however, and the vehicle folks want the 40lbs back. Any other added input to justify the capability?*

Hard to believe that it has come to this this early! Maybe they can keep the possibility open for an add-on heater to be added if the mass margins improve. We certainly got by in the lm for three days with no hot water, so I cannot say it is mandatory.

Thanks again for your help in assisting with these areas,

Rick A. Scheuring, DO

From: Tom Mattingly

Rick,

Sorry to have taken so long to respond to your inquiries. After reviewing your document, I decided it would be easier to provide this in a narrative form rather than fill in your form. Hope it helps.

Apollo EMU

I had the opportunity to serve as the CB representative to the EMU development team and work with them through qualification and crew training. The following are some recollections that were triggered by reading the user's comments

EMU development was managed by CSD. We knew it was a baby spacecraft and the reason for Apollo. It had to work flawlessly, be robust, allow productive activity and take a minimum of training and real time attention. The development program, from the time I joined (~1967) was on of exercising it in every conceivable operational scenario in a vacuum chamber and then fixing whatever didn't work. The primary issues were glove tactility, suit mobility, contingency capabilities and crew controls.

In the beginning, suits were so expensive that they were only produced for designated flight crews. (3 suits each, a primary, a backup and a training unit). This meant that test subjects had to use the prime and b/u crew training suits for all development work. In other words, the suits and the subjects never matched. As a result, it was a long time before we were able to sort out whether problems were due to design shortcomings or misfitting suits. We worked through several versions of so called constant volume knee, waist, elbow and shoulder joints. Essentially, these were nearly constant volume with the pressure loads carried through cables. All had a lot of friction when the suit was pressurized. We did some work on mechanical joints , but these didn't mature until shuttle. The great amount of energy needed to move around was at first attributed to the fact that misfitting suit joints were not co-located with the subject's joints. We finally put this to bed and concluded that the problem was the fact that every motion required compressing the suit volume, a potentially fatiguing activity. This didn't turn out to be as bad as we'd thought, but it took a long time to figure out what were our real issues. By the way, our test program did not identify any knee joint problems. I believe this was for two reasons. First, we did all of our testing standing up, climbing stairs and walking. Second, given the weight of the EMU, having a semi-rigid knee joint actually made life easier for us. However, before you decide to unload the suit with artificial load relief, take a look at the impact they have on test operations. The use of load relief was so onerous that when it came time to do our final thermal-vacuum tests, I elected to walk unencumbered by load relief. I thought the potential for getting tangled up in pulleys, cables, etc., that I could not see or reach, was a greater hazard than the risk of losing suit pressure and having the whole thing fall on me.

Gloves were the most obvious challenge. We had a requirement that the suit, including gloves, had to be capable of operating from lunar noon through a fully shadowed location. This meant that the gloves required a significant level of thermal protection. Since we could never find any way to actively cool the hands, we had to resort to placing thermal insulation on the outside of

the gloves. Multilayer insulation worked on the back of the glove, but since we intended to pick things up and handle them, the palm and interior required a thermal barrier that could withstand abrasion and compression. At one point, believing that the act of making a fist or gripping a tool required compressing the suit, we even made a set of glove bladders that were molded into the gripping shape. The theory was that it would take less energy total to periodically open the hand against pressure than to always have to squeeze. These gloves were almost impossible to don when your hands were sweaty and did nothing to relieve the hand fatigue. The real issue was simply the need to compress the palm side insulation. Compare the IV gloves with EV gloves to see how significant this is. We did look at reducing the amount on insulation and carrying a set of mittens for hot spots, but rejected this as too cumbersome. We got around the lack of tactility by simply designing tools that required no dexterity to operate. If you go after improved insulation, don't forget that once the insulation heats up, its really hard to remove the thermal content. For example, one of our final tests was to demonstrate I could pick up a two hundred something degree rock and hold it for 15 seconds or so. The test used a metal bar that was heated to the desired temperature. I was to grasp it and hold for the required period. Worked for ten seconds or so until the inside of the glove became very hot. Fortunately for me, I was using one of the suits that didn't fit and could pull my hand entirely out of the glove. It would have been a really bad scene if the suit had fit properly. Perhaps contemporary materials will allow developing a thin, flexible mesh with high conductivity that could be used to interface with an active heat rejection system for future explorers. Making the gloves useful is the biggest challenge I see in making lunar activity productive.

Our goal was to make the suit operation as autonomous as possible and providing confidence in its contingency capabilities. The OPS was adopted late in the development after a significant degree of deliberation. If we're going to send folks out, we need to provide a modicum of protection against life threatening events, no matter how improbable. The more routine we make this, the more likely we are to need protection. Rather than carry large quantities of O2, it would be worth exploring the ability to create a self sealing layer on the inside of the suit to stem the loss of pressure. It doesn't have to be a perfect barrier, just enough to minimize the leakage due to minor punctures, leaks, cracks, etc., the most debilitating event can be one that allows the helmet to fog. It may be worth while to develop a way to periodically spray pure O2 on the front of the helmet, which can also reduce the local CO2 concentration during periods of exertion. The cooling system should also be self-healing wrt leaks. Retain ability to make/break gas connections in a vacuum and provide contingency O2 on rovers, etc. Always use the buddy system when conducting and EVA.

As we discussed, heart rate is not a reliable indication of work load. Perhaps the most important physiological parameter is hydration. It would be a good thing if there were a simple, non-invasive way to evaluate hydration in real time. Its been my experience that you have to force yourself to drink often, especially in the suit, because its generally a nuisance task.

Perhaps the most important recommendation would be to stop trying to maximize every minute of surface time with pre-planned timelines, etc. The ISS folks seem to have learned this. If you want to explore, let the explorer pick their own pace and focus. The next set of missions should not be short sorties, but part of an on-going program.

Random thoughts on space flight in general
Be very careful about PIs who want to have windows w/o IR protection. Its an insidious trap with potentially serious consequences if someone forgets to put up a filter.

Its my impression that the food in Apollo was uniformly OK pre-flight and absolutely unattractive in flight. I did not have that experience in shuttle. Makes me think it is either O2 toxicity, reduced pressure or, less likely, unaccelerated flight.

Fluid shifts to head almost immediately upon arrival on orbit. Found that sinuses tended to stop frequently and sometimes for prolonged duration. Annoying only. During shuttle, we noticed that five minutes on the treadmill would immediately clear the sinus.

The only comment in your list that I didn't understand was the one about CMP boredom. I thought that the solo time was really precious. In fact, routine operational chores and flight plan maintenance was a nuisance. To get around this, we had Hank Hartsfield (CSM Capcom) run the flight plan when we had AOS so I could look out the window and contemplate what there was to observe. I'd resume flight plan responsibility on the back side. Thanks to some superb geology training, you could see an awful lot and test various hypotheses. And I didn't have to listen to country and western music!

As we discussed on the phone, it is important that the flight surgeons serve as the crew's advocate. Put science and experimentation in another office to avoid conflicts of interest. This was not always the case during Apollo but I believe that Mike Berry turned this around during the early shuttle days. Don't let it revert to the old ways!

Hope there's something useful in here but it may be like the kid looking for the pony.

From: Jim Lovell

Thank you for inviting me to attend the meeting concerning medical requirements for future space operations. Unfortunately, I will not be able to attend on Jun 7-9 in Houston. However, I do have some comments concerning your questions in the letter.

With the exception of obtaining valuable information for lunar surface operation, it appears more valuable information can be obtained from shuttle crews. Over a hundred flights were flown with equipment and systems much improved from the Apollo days. I never landed on the Moon after two flights, but let me answer some of the questions you inquired about.

1. I personally was not bothered by the noise level in the CM on 8 and the CM was shut down on 13. It seems to me, the orbiters being much larger than the CM, the noise levels should be lower. On Apollo, we had ear plugs for communications and were helpful in reducing noise to the ear.
2. The UCD was only used for EVA; operation – lunar surface, etc. The CM was equipped with a relief tube. Haise did wear his UCD on 13 and it resulted in a urinary infection. For EVA operations, I don't see how you can improve the device.
3. The sleep restraint system worked fine in Apollo, an I suspect they worked just as well in the oribiters. For lunar surface, hammocks could be rigged in the LM. You will have to ask others on how good they were.
4. The temperature was well balanced in the CM by utilizing heat from the electronic systems and dissipating excess heat by a radiator. On 13, however, with most of the electrical systems shut down we were losing heat faster than the sun could provide. The temperature gradually dropped to about 34 F by the time we reentered the atmosphere. WE could have put on our pressure suits, but they were too bulky for three men in the LM> It appears shuttle crews operate in-flight in shorts and tee shirts. If that will be the uniform on lunar flights, I suggest some thermal protection in case of electrical failure.
5. There is no question that a medicine to combat fatigue should be onboard spacecraft. We took Dexedrine just before reentering the atmosphere to make sure its effect would stay with us through the landing. Take the medicine too early and their effectiveness would end and increase the fatigue.
6. It has been 35 years since I flew on Apollo 13. I couldn't possibly answer this question.

I hope I have provided some insight into your questions. As I previously mentioned the best source of advice should come from shuttle and space station crews. Us old Apollo guys are getting old and our memories are fading fast!

Captain Lovell
Lovell Communications

To Harrision Schmitt:

Another question was raised by the ECLS folks about cabin temperature. It was noted during the Summit that the CM and LM cabin temps were "cool" however ECLS seems to remember that the CM/LM during lunar orbit was "warm." they are trying to set the temperature req for mission phases but needed this clarification.

The "astronaut memory" is in the transcripts, even though it is a tough grind to find what you want. Some people really should review them in detail for astronaut comments on how systems performed.

My "memory" is that I was never too cool (the Apollo 13 problem may be coloring memories of ECLS). If anything, I seem to remember being warm but not uncomfortably so in both vehicles. I don't recall that the ~45min in lunar night on each orbit made a noticeable difference - CMPs may have notice this as they saw many more cycles.

If the LM is in sunlight at the poles, its heating will be similar to the equator. If it is in the dark part of the outpost time, then significant cooling may have to be counteracted.

Again, please encourage these folks to review the transcripts rather than trying to rely on 35 year old memories of astronauts or others.

Harrison

Dr. Schmitt-

Pendulum is swinging back to water landings. A question has come up about whether you were in pressurized suits for isolation or just chemical suits. I know A11 & 12 were in those suits but can't recall if you wore the pressurized EVA suits for re-entry and landing.

We were in our constant wear garments, not the pressure suits. At some point the program decided that separation of the SM from the CM was not a true "change of configuration" that posed a significant hazard. You will have to research the flight plans to see when this change was made, but it may have been for 13 although that may have been a real-time decision based on everything else that was going on.

Harrison

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Medical requirements for the future Crew Exploration Vehicle (CEV), Lunar Surface Access Module (LSAM), advanced Extravehicular Activity (EVA) suits and Lunar habitat are currently being developed. Crews returning to the lunar surface will construct the lunar habitat and conduct scientific research. Inherent in aggressive surface activities is the potential risk of injury to crewmembers. Physiological responses to and the operational environment of short forays during the Apollo lunar missions were studied and documented. Little is known about the operational environment in which crews will live and work and the hardware that will be used for long-duration lunar surface operations.Additional informantion is needed regarding productivity and the events that affect crew function such as a compressed timeline. The Space Medicine Division at the NASA Johnson Space Center (JSC) requested a study in December 2005 to identify Apollo mission issues relevant to medical operations that had impact to crew health and/or performance. The operationally oriented goals of this project were to develop or modify medical requirements for new exploration vehicles and habitats, create a centralized database for future access, and share relevant Apollo information with the multiple entities at NASA and abroad participating in the exploration effort.

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