Send information for publication on this page
to: Mark Campbell, M.D.
420 N. Collegiate Dr., #300
Paris, TX 75460
mcamp@1starnet.com

Human Spaceflight Health Systems for the Constellation Project

Richard (Rick) A. Scheuring, DO, MS, FAAFP, Jeffrey (Jeff) A. Jones, MD, MS, FACS, FACPM, and James D. (JD) Polk, DO, MS, FACOEP

The Constellation Program Office has been tasked with developing the exploration vehicular architecture. NASA, with the prime contractor Lockheed-Martin, will build The Crew Exploration Vehicle or CEV (Orion) over the next 5 years. The architecture includes initial flights of the CEV to ISS and allows 3-6 crewmembers to be rotated to the station, beginning in 2013-2015. This is after the Shuttle is retired and construction of the ISS is complete. In the 2017-2019 timeframe, lunar missions will begin and will lead to a rapid build-up of a lunar base. This Lunar Outpost will allow for the validation of power, life support, and resource utilization systems for future long duration exploration missions.

The medical operations division, in conjunction with the exploration medical capabilities (EXMC) team at NASA-JSC, is developing the human spaceflight health systems. The exploration medical support system will be tiered to match the mission profile and duration according to NASA's Standards, as shown in Table 1.

The Lunar Outpost will eventually have a dedicated medical support area, which will include a telemedical workstation, imaging, and treatment zone, as well as exercise countermeasures hardware. The medical kits needed to provide for the initial lunar capabilities (level of care III) are summarized in Table 2. Note that for CEV to ISS missions, only the small, mini-medical kit will be flown to handle the usual expected physiological adaptation to microgravity, and any minor contingencies.

Historically, the Apollo medical kit weighed 3.8 pounds. However, the Apollo kits were based on 3 male crewmembers for a total mission duration of less than 2 weeks. Orion is based on mixed-gender crews of 4-6 for much longer missions. Apollo was a "best guess," based on limited space medical knowledge and would be insufficient to meet even Constellation Level 1 Medical Care. The Apollo medical kit was insufficient even during Apollo, as evidenced by the need for the Apollo crewmembers to ration their medications because of insufficient supply. By comparison, Shuttle Medical Kits (SOMS) weigh 40.6 lbs to support 6-7 crewmembers on a 14-day mission.

The CEV and lunar lander (Lunar Surface Access Module or LSAM) will also have radiation monitoring hardware and shielding to protect crewmembers against possible solar particle events, during mission phases outside of the Earth's protective magnetosphere. For lunar sortie missions, routine ambulatory medical needs will be met with a standard spaceflight medical kit. Additionally, two-way private audio/video is required for performing Private Medical Conferences with the flight surgeon. Trauma management and advanced life support kits will be used to stabilize crewmembers experiencing lunar surface contingencies. Data from medical monitoring devices may be transmitted to the ground for further diagnostic purposes. Some medical equipment will need interfaces for power, data, and pressurized breathing gas (with or without oxygen concentration) for certain medical conditions or for environmental contingencies (depressurization, fire, toxic release). The crew will don Personal Protective Equipment (PPE) during a toxic spill clean up or a dust-ridden activity. A crewmember with a significant illness or injury will be stabilized using lunar lander-based medical equipment in preparation for ascent and transfer to the CEV.

Extravehicular Activity (EVA) will be a main component of lunar surface activity. The suit team is considering new concepts for suit mass reduction, distribution of load/center of gravity, glove fit and dexterity, life support systems, biomedical telemetry, and information display. This is all designed to reduce crew overhead, minimize injury within the suit, and enhance task performance. These concepts are based in part from the recommendations provided in the Apollo Medical Operations project. Another design objective is providing feedback to the EVA crew for navigation, consumable supply and physiological/thermal parameters. Another design contingency includes up to 144 hours in the spacesuit, in case of loss of vehicular pressure on the Moon, which would require an urgent return to Earth. This will involve provision of a survival atmosphere (oxygen, CO2 scrubbing), crew hydration, nutrition and waste management. With frequent EVAs, the possibility of decompression sickness (DCS) must

TABLE 1: LEVELS OF CARE IS MATCHED TO MISSION DURATION AND DESTINATION.

Level of Care	Mission	Example Capability
I	LEO* < 8 days	SMS, BLS, First Aid
II	LEO <30 day; e.g. STS EDOMP	Level I + Clinical Diagnostics, Ambulatory Care, Private Audio, (+/-Video)
III	LEO > 30 day (ISS or Lunar Sortie)	Level II+ Limited Advanced Life Support, Trauma Care, Telemedicine, Minor Surgical and Dental Care
IV	Lunar > 30 day (Outpost)	Level III+ Imaging, Sustainable ALS
V	Mars Expedition	Level IV+ Autonomous ALS, Basic Surgical Care

*Low Earth Orbit; STS= Shuttle Transport System; EDOMP= Extended Duration Orbiter Medical Project; SMS= Space Motion Sickness; BLS= Basic Life Support; ALS= Advanced Life Support

TABLE 2: EXAMPLE HARDWARE AND MASS/VOLUME ALLOCATION FOR SUPPORT OF LUNAR MISSIONS.

Item for Lunar Sortie	Mass	Size	Development Concept
Medical Kit	10 lbs	10x7x6 in	COTS*
Medical Contingency Kit	30 lbs	32x12x16 in	Modified COTS
EVA Contingency Response Kit	16 lbs	16x16x8.5 in	Modified COTS
Environmental Health Kit	7.5 lbs	7x7x9 in	Modified COTS
Exercise Equipment	5-20 lbs	TBD	Technology Development Required

*COTS= Commercial Off-The-Shelf

SMA JEFF MYERS YOUNG INVESTIGATOR AWARD

The Space Medicine Association's Jeff Myers Young Investigator Award is presented to a young investigator who is the primary author of an outstanding presentation in the area of Aerospace Medicine presented at the current Annual Scientific Meeting of the Aerospace Medical Association. In addition to being the primary author, the work must be original and the young investigator must be presenting at the Annual Scientific Meeting for the first time. The Award is intended to encourage young investigators new to the field of Aerospace Medicine.

The applicant must submit a draft manuscript of their presentation to the chair of the Jeff Myers Young Investigator Award sub-Committee. To be considered for the 2008 award, manuscripts must be submitted by March 15, 2008 to:

K. Jeffrey Myers, M.D.
Space Medicine Branch
Young Investigator Award Chair
P.O. Box 540305
Merritt Island, Florida 32954
Phone: (321) 867-2026
jeffrey.myers-1@kmail.ksc.nasa.gov

also be anticipated. Operating the habitat at a lower pressure (7.6 psi) with oxygen concentration may help reduce the DCS risk. Having a suit with a variable pressure of operation, up to habitat pressure, is another means of reducing risk. This would also be a means of early onset treatment of DCS symptoms. An airlock that can raise atmospheric pressure above that of the habitat pressure would allow for additional capability to treat DCS, although it is unrealistic to expect a true Table 6 level of treatment to be delivered.

For the Lunar Outpost missions, successive buildup of the habitat infrastructure will occur and will eventually include dedicated medical and fitness areas. The medical area will allow for the periodic health status acquisition via a medical diagnostic station with telemedical transmission capability. The medical station will have improved autonomy for medical contingency response, including sustainable advanced trauma and life support. This will allow for the development of an exploration medical support system with completely autonomous capability to be used for future exploration missions. Possible technology developments for the medical workstation include: 1) an oxygen concentrator; 2) generation of intravenous fluids; 3) non-invasive or minimal invasive diagnostic and therapeutic modalities; and 4) differential diagnostic and preventive medicine maintenance software.

A very small exercise device will be flown for crew use during the outbound and return mission phases as well as between EVA days. The precise level of activity and type of countermeasures required for maintaining physiological systems in 1/6 G with long duration spaceflights has yet to be defined. However, an exercise countermeasure program that incorporates neurovestibular system maintenance will be built into the medical support system. The equipment for this countermeasure function will be more robust for the Lunar Outpost missions than found on the lunar sortie missions. Exercise will also assist in the behavioral health and performance (BHP) program. Key components of the BHP program will be regular private family conference (PFC), e-mail to family and colleagues, recreational activities (which involve both equipment and time allocation), and episodic psychological support interaction.

Cold food storage in the habitat may expand the types of food available to the crew. The development of systems to effectively grow plants, for food or air revitalization, will make considerable progress towards crew autonomy during Mars missions. The potential biological toxicity of lunar dust is not completely characterized at present, but lunar dust is clearly an irritant to the mucous membranes and respiratory system of humans, and management of lunar dust will be a major design driver for the surface habitat.

In summary, the medical support system for the Constellation Project will be the most efficient and advanced of any flown in space. This system will have as small an overall medical footprint as is possible for the type of mission that will be flown. It will be designed to provide health maintenance, EVA monitoring, contingency response, diagnosis and treatment as defined in the levels of care section of the Spaceflight Health Standards document. This system will increase in capability as destination and duration moves farther away from Earth. The design will allow for an increasingly autonomous crew health care and maintenance as the mission architecture expands.