

spaceflight given the existing boundary conditions. However, returning to the Moon will revive support concepts created for the Apollo program. Many new factors including, but not limited to partial gravity, inability for 'relatively' quick return to Earth, and remote medical support capabilities present new challenges compared to LEO. This panel is designed to stimulate thought and discussion about the next steps that are needed to develop medical support programs necessary for lunar missions. The panel will present potential medical scenarios, current research analyzing partial gravity locomotion biomechanics, an ESA initiative tasked with researching possible technologies and concepts to support lunar exploration missions, and a lunar analogue to test possible support scenarios to refine operations. The first presentation describes the ESA "Moon Village" concept to establish the background parameters for the following presentations. It will lay the foundation by describing design mission scenarios, a subset of medical concerns to address, and describe the LUNA analogue facility developed at the ESA European Astronaut Centre (EAC). The second presentation outlines a subset of possible medical challenges that could occur in a short duration (days to a few weeks) lunar exploration mission with up to 4 crew members. The third presentation describes a subset of possible medical challenges that a multinational crew up to 10 astronauts and commercial crewmembers could face in an established lunar base with a mission duration of up to several months. The fourth presentation describes research involving a weight offloading treadmill to assess biomechanics of locomotion in various partial gravity configurations. The final presentation outlines the "Spaceship EAC" initiative that is a multi-disciplinary innovation-driven team within EAC and beyond which aims to utilize the spaceflight experience of EAC to develop and validate operational concepts and low-TRL level technologies in support of lunar human exploration scenarios. These presentations will provide basis for the panel discussion and encourage action in the field of medical support needed for human exploration of the Moon.

[095] MEDICAL CHALLENGES AND CONSIDERATIONS FOR A SHORT DURATION LUNAR EXPLORATION MISSION

R.A. Anderton¹, B. Posselt⁴, M. Komorowski², R.S. Whittle⁶, K. Fong⁵ and P.D. Hodkinson³

¹Medical Department, UK Civil Aviation Authority, Gatwick, United Kingdom; ²Intensive Care Unit, Imperial College London, London, United Kingdom; ³RAF Centre of Aviation Medicine, Hitchin, United Kingdom; ⁴Royal Air Force, Bedfordshire, United Kingdom; ⁵University College London, London, United Kingdom; ⁶Cranfield University, Cranfield, United Kingdom

(EDUCATION - PROCESS)

MOTIVATION: As we near the 50th anniversary of the first human mission to the Moon there is significant international interest in returning. This may be as a proving ground for future exploration of Mars, to establish a permanent research base on the Moon or commercial opportunities from the exploitation of lunar resources. The initial missions, however, are likely to be exploratory, temporary and short duration (days-weeks) in nature, likely consisting of 3-4 crewmembers. As with the Apollo missions, conditions will be austere with limited support available except for that able to be provided by remote communications, carried on-board or provisioned in advance. This places increased emphasis on appropriate mission planning and, as an integral part of this, medical planning and risk assessment. This will need to incorporate the likely activities to be undertaken and the specific challenges to be faced in light of the stringent limitations on resources, support and medical skills. A dedicated physician may not be part of the crew; instead members will need to undergo focused medical training based on the most probable medical occurrences.

OVERVIEW: Lunar exploration missions are likely to involve multiple extravehicular activities (EVAs) for exploration in the lunar partial gravity environment and be associated with different medical challenges to those of established ISS operations in low Earth orbit and spaceflight analogue environments. Three particular medical scenarios of concern that will be discussed are the management of severe trauma, loss of spacesuit pressurization during lunar EVA and management of acute radiation sickness. For each of these scenarios, we will discuss the

possible impact on crew health and mission objectives and the options for optimal management in light of the severe constraints aforementioned. For the management of injuries occurring during EVAs, the European Space Agency has developed and tested the Lunar Evacuation System Assembly (LESA), a foldable rescue device on wheels that opens above a fallen astronaut to lift and transport them. **SIGNIFICANCE:** Achieving a successful return to the Moon, in preparation for the establishment of a permanent base, will require a thorough assessment of the medical risks involved and extensive medical preparation focusing on the medical scenarios posing the highest threat to crew health and mission objectives.

Learning Objectives:

1. To gain an understanding of the anticipated medical challenges to support lunar exploration missions and areas that require further investigation and consideration to support such missions.

[096] MEDICAL CHALLENGES AND CONSIDERATIONS FOR AN ESTABLISHED LUNAR BASE

B. Posselt¹, R.A. Anderton², M. Komorowski³, B. Healey⁴, T.G. Smith⁵, R.S. Whittle⁶, K. Fong⁷ and P.D. Hodkinson¹

¹RAF Centre of Aviation Medicine, Hitchin, United Kingdom; ²Authority Medical Section, Civil Aviation Authority, Kingston upon Thames, United Kingdom; ³Intensive Care Unit, Imperial College London, London, United Kingdom; ⁴European Space Agency, Cologne, Germany; ⁵King's College London, London, United Kingdom; ⁶Cranfield University, Cranfield, United Kingdom; ⁷University College London, London, United Kingdom

(EDUCATION - PROCESS)

MOTIVATION: An established base on the lunar surface, perhaps akin to Antarctic research station operations, offers great potential for lunar exploration, science and would act as a stepping-stone for future missions to Mars. A permanent habitat is likely to have more personnel (>6-10) and still be of a multinational nature but perhaps with more regular commercial crewmembers. It is an exciting challenge to build and progress from the lessons learned and international relationships developed during operation of the ISS. However, an established lunar base will pose a number of different medical considerations. **OVERVIEW:** This talk highlights some key requirements for maintenance of crew physical and mental health and performance, as well as several expected medical challenges associated with an established lunar base, some of which are informed by established operation of Antarctic bases. For the larger group of astronauts a designated medical facility and staff may be deemed necessary although this will need to be informed by consideration of the likely activities and associated risks. For example, a lunar launch and landing facility may introduce risk of mass casualty events. As with long duration spaceflight in low Earth orbit consideration must be given to how astronauts will adapt but this time to living in partial gravity and thought must be given to an appropriate physical conditioning program to maintain health and performance. Additionally novel medical conditions may develop; the Apollo crewmembers reported some irritation symptoms of the skin, eyes and upper airways raising concern that exposure to respirable lunar dust could be detrimental to human health. The potential health effects of chronic exposure are unknown. Finally, to allow more rapid extravehicular activity it is likely that a lunar habitat will be operated at a reduced barometric pressure, partially countered by an increase in the percentage of oxygen, and that the overall atmosphere will be mildly hypoxic compared with Earth at sea level, introducing chronic hypoxia as an additional physiological challenge in this setting. **SIGNIFICANCE:** Significant progress is being made to address the potential medical challenges of lunar missions. Efforts will need to be multinational in their approach, to address the needs of all nations involved. This presentation reviews current knowledge to highlight gaps and direct future research to support the establishment of a lunar base.

Learning Objectives:

1. To gain an understanding of the anticipated medical challenges to support an established lunar base and areas that require further investigation and consideration to support such missions.