Paper ID: 87817
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35th IAA SYMPOSIUM ON SPACE AND SOCIETY (E5)
Space Architecture: Habitats, Habitability, and Bases (1)

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DESIGNING A LUNAR HEALTH MAINTENANCE FACILITY (HMF) FOR REMOTE SURGERY: SPATIAL AND ARCHITECTURAL CONSIDERATIONS FOR ADVANCED ROBOTIC SURGERY IN SPACE

Abstract

Crew Health is a significant component of any human space mission. For the most part, however, health issues in space have mostly been addressed with the help of medical kits and supplies provided onboard, along with limited paramedical training supported by telemetry. As we plan for longer term missions and potential human settlement on the Moon, we need to consider the development of better Health Maintenance Facilities (HMFs) that account for surgery in the case of appendicitis, peptic ulcer, intestinal obstruction, cholecystitis, diverticulitis, or trauma. Latest developments in robotic surgery processes have made this possible, but a full architectural solution that incorporates these new technologies is yet to be developed. The current paper offers some initial experiments and considerations for the development of such a Lunar HMF which incorporated remote robotic surgery. Some of the design challenges included methods for physical restraint of patient during surgery, accessibility of instrumentation, maintenance of sterile environment, and containment of bodily fluids. In developing the design, methods like Hierarchical Task Analysis (HTA) and Spatial Decision Support System (SDSS) were employed to allow for various medical processes to be incorporated in the limited space of the HMF. We considered the kits provided for Skylab (Minor Surgery Kit), Space Shuttle (Shuttle Orbiter Medical Kit), Concept- Space Station Freedom (Health Maintenance Facility), and the International Space Station (Advanced Life Support pack) for the instrumentation. With a focus on the containment of bodily fluids, minimally invasive surgery (MIS, laparoscopic surgery) and robotic-assisted mini-invasive surgery (RAMIS) have been considered. Additionally, since 2022, developments in Machine Learning and Artificial Intelligence have also enhanced robotic surgery through visual and haptic feedback, such as the Smart-Tissue Autonomous Robot (STAR), which performed an anastomosis of the porcine intestine, and more recently spaceMIRA (Miniaturized In Vivo Robotic Assistant), which performed the first remote simulated surgical procedure on 10 February 2024. So, these are also being factored into the design of the HMF. Finally, due to the latency in Earth-Moon communication, technology like PRIMUS (PeRformance management of smart healthcare applications requireMents based on network resoUrce Slicing) have also been included. The results and considerations discussed in this paper will help with the integration of emerging technologies in the design of future Lunar Health Maintenance Facilities and provide a better standard of healthcare for astronauts on long term missions. The research also has implications for perioperative and remote health care for isolated environments here on Earth.