27th IAA SYMPOSIUM ON HUMAN EXPLORATION OF THE SOLAR SYSTEM (A5)
Interactive Presentations - 27th IAA SYMPOSIUM ON HUMAN EXPLORATION OF THE SOLAR SYSTEM (IP)

Author: Mr. Mikhail Denisov
Bauman Moscow State Technical University, Russian Federation

Dr. Vera Mayorova
Bauman Moscow State Technical University, Russian Federation
Dr. Olga Bannova
University of Houston, United States
Ms. Veronika Kameneva
Bauman Moscow State Technical University, Russian Federation
Prof. Vladimir Igritsky
Bauman Moscow State Technical University, Russian Federation

DESIGN STRATEGY FOR INTEGRATING RADIATION PROTECTION AND LIFE SUPPORT SYSTEMS IN SPACE HABITATS

Abstract

Planning for crewed missions to celestial bodies in the Solar system is crucial for expansion of space exploration. Preparing for such crewed space missions requires diligence in details and extensive testing of complex engineering systems including autonomous systems and scientific and technical provisions.

However, there are major limitations of long duration human presence beyond LEO (Low Earth Orbit) that include radiation hazard and logistics constraints such as food, air, and water regular re-supplies. This paper focuses on two critical aspects for advancing crewed space flight: reducing the ionizing radiation dose received by the crew during the mission; and improving technologies for close-loop life support systems. The proposed design concepts were developed for a schematic design of a Universal Crewed Spacecraft (UCS) complex – a project conducted within the framework of the International Youth Scientific Workshop "Space Development: Theory and Practice - 2023" (SDTP-2023).

According to the research analysis presented in the paper, embedding biological subsystems in the main LSS offers potential for increasing its close-loop capabilities. Characteristics of the BLSS system were estimated in relation to the number of the crew members and based on the results from "Vitacycle" and "Lada" experiments and their analysis. Oxygen and water supply for the crew is provided by the system of high-temperature electrolysis of carbon dioxide and water applying Boudoir reaction and a system for collecting human moisture condensate.

The presented in this paper radiation shielding design for long-duration missions in Venus's orbit is a four-layer package consisting of a protective body, a polymer layer saturated with hydrogen atoms, a ceramic layer of boron carbide, and a thin layer of secondary (and neutron) radiation decelerator represented by lead. The proposed concept of radiation protection allows to reduce the equivalent dose for the crew of the UCS to values comparable to the exposure of Group A personnel of nuclear power plants (about 20 mSv/year). Utilizing local radiation protection reduces this value even further.

The paper concludes with major aspects in holistic design strategy that require high level integration of systems and crew operations and support. The results of the UCS design development include optimization of radiation protection in relation to mission needs and effective utilization of spacecraft surface; increase of close-loop efficiency of LSS with integration of biosystems; overall feasibility evaluation of development of the UCS.