DOWNLOAD SPACE RADIATION HAZARDS AND THE VISION FOR SPACE EXPLORATION REPORT OF A WORKSHOP BY AD HOC COMMITTEE ON THE SOLAR SYSTEM RADIATION ENVIRONMENT A 2006 PAPERBACK

Space Radiation Hazards and the Vision for Space Exploration

Fulfilling the President's Vision for Space Exploration (VSE) will require overcoming many challenges. Among these are the hazards of space radiation to crews traveling to the Moon and Mars. To explore these challenges in some depth and to examine ways to marshal research efforts to address them, NASA, NSF, and the NRC sponsored a workshop bringing together members of the space and planetary science, radiation physics, operations, and exploration engineering communities. The goals of the workshop were to increase understanding of the solar and space physics in the environment of Earth, the Moon, and Mars; to identify compelling relevant research goals; and discuss directions this research should take over the coming decade. This workshop report presents a discussion of radiation risks for the VSE, an assessment of specifying and predicting the space radiation environment, an analysis of operational strategies for space weather support, and a summary and conclusions of the workshop.

Building Habitats on the Moon

Designing a habitat for the lunar surface? You will need to know more than structural engineering. There are the effects of meteoroids, radiation, and low gravity. Then there are the psychological and psychosocial aspects of living in close quarters, in a dangerous environment, far away from home. All these must be considered when the habitat is sized, materials specified, and structure designed. This book provides an overview of various concepts for lunar habitats and structural designs and characterizes the lunar environment - the technical and the nontechnical. The designs take into consideration psychological comfort, structural strength against seismic and thermal activity, as well as internal pressurization and 1/6 g. Also discussed are micrometeoroid modeling, risk and redundancy as well as probability and reliability, with an introduction to analytical tools that can be useful in modeling uncertainties.

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predicting the space radiation environment, an analysis of operational strategies for space weather support, and a summary and conclusions of the workshop.

Managing Space Radiation Risk in the New Era of Space Exploration

As part of the Vision for Space Exploration (VSE), NASA is planning for humans to revisit the Moon and someday go to Mars. An important consideration in this effort is protection against the exposure to space radiation. That radiation might result in severe long-term health consequences for astronauts on such missions if they are not adequately shielded. To help with these concerns, NASA asked the NRC to further the understanding of the risks of space radiation, to evaluate radiation shielding requirements, and recommend a strategic plan for developing appropriate mitigation capabilities. This book presents an assessment of current knowledge of the radiation environment; an examination of the effects of radiation on biological systems and mission equipment; an analysis of current plans for radiation protection; and a strategy for mitigating the risks to VSE astronauts.

Turning Dust to Gold

The expansion of our civilization to the Moon and beyond is now within our reach, technically, intellectually and financially. Apollo was not our last foray into the Solar System and already science fiction is finding it difficult to keep ahead of science and engineering fact. In 1807, few people anticipated the Wright Brothers' human flight a hundred years later. In 1869, only science fiction writers would have suggested landing people on the Moon in 1969. Similarly, other great inventions in mechanics and in electronics were not envisaged and therefore the technologies to which those inventions gave birth were only foreseen by a tiny group of visionaries.

American Book Publishing Record

Astronauts face unique health-related risks during crewed space missions, and longer-duration missions that extend to greater distances in our solar system (including to the Moon and Mars) will likely increase those risks. Cancer risks due to ionizing radiation exposure are one of these health-related risks. Assessing, managing, and communicating radiation-induced cancer risks associated with spaceflight are challenging because of incomplete knowledge of the radiation environment in space, limited data on radiation-induced cellular damage mechanisms, lack of direct observations from epidemiological studies, and the complexities of understanding radiation risk. At the request of the National Aeronautics and Space Administration (NASA), an ad hoc committee of the National Academies of Sciences, Engineering, and Medicine convened to provide advice on NASA's proposed updates to their space radiation health standard, which sets the allowable limit of space radiation exposure throughout the course of an astronaut's career. Space Radiation and Astronaut Health: Managing and Communicating Cancer Risks provides the committee's recommendations and conclusions regarding the updated space radiation health standard, NASA's radiation risk communication strategies, and a process for developing an ethics-informed waiver protocol for long-duration spaceflight missions.

Space Radiation and Astronaut Health

A major objective of the International Space Station is learning how to cope with the inherent risks of human spaceflightâ€\"how to live and work in space for extended periods. The construction of the station itself provides the first opportunity for doing so. Prominent among the challenges associated with ISS construction is the large amount of time that astronauts will be spending doing extravehicular activity (EVA), or \"space walks.\" EVAs from the space shuttle have been extraordinarily successful, most notably the on-orbit repair of the Hubble Space Telescope. But the number of hours of EVA for ISS construction exceeds that of the Hubble repair mission by orders of magnitude. Furthermore, the ISS orbit has nearly twice the inclination to Earth's equator as Hubble's orbit, so it spends part of every 90-minute circumnavigation at high latitudes,

where Earth's magnetic field is less effective at shielding impinging radiation. This means that astronauts sweeping through these regions will be considerably more vulnerable to dangerous doses of energetic particles from a sudden solar eruption. Radiation and the International Space Station estimates that the likelihood of having a potentially dangerous solar event during an EVA is indeed very high. This report recommends steps that can be taken immediately, and over the next several years, to provide adequate warning so that the astronauts can be directed to take protective cover inside the ISS or shuttle. The near-term actions include programmatic and operational ways to take advantage of the multiagency assets that currently monitor and forecast space weather, and ways to improve the in situ measurements and the predictive power of current models.

Radiation and the International Space Station

As part of the Vision for Space Exploration (VSE), NASA is planning for humans to revisit the Moon and someday go to Mars. An important consideration in this effort is protection against the exposure to space radiation. That radiation might result in severe long-term health consequences for astronauts on such missions if they are not adequately shielded. To help with these concerns, NASA asked the NRC to further the understanding of the risks of space radiation, to evaluate radiation shielding requirements, and recommend a strategic plan for developing appropriate mitigation capabilities. This book presents an assessment of current knowledge of the radiation environment; an examination of the effects of radiation on biological systems and mission equipment; an analysis of current plans for radiation protection; and a strategy for mitigating the risks to VSE astronauts.

Managing Space Radiation Risk in the New Era of Space Exploration

The purpose of the workshop was to define requirements for the development and evaluation of high performance shield materials and designs and to develop ideas regarding approaches to radiation shielding.

Shielding Strategies for Human Space Exploration

To meet the objectives of the Vision for Space Exploration (VSE), NASA must develop a wide array of enabling technologies. For this purpose, NASA established the Exploration Technology Development Program (ETDP). Currently, ETDP has 22 projects underway. In the report accompanying the House-passed version of the FY2007 appropriations bill, the agency was directed to request from the NRC an independent assessment of the ETDP. This interim report provides an assessment of each of the 22 projects including a quality rating, an analysis of how effectively the research is being carried out, and the degree to which the research is aligned with the VSE. To the extent possible, the identification and discussion of various cross-cutting issues are also presented. Those issues will be explored and discussed in more detail in the final report.

Review of NASA's Exploration Technology Development Program

This report consists of a collection of 225 abstracts of radiation research sponsored by NASA during the period 1986-1990. Each abstract has been categorized within one of four discipline areas: Physics, Biology, Risk Assessment and Microgravity. Topic areas within each discipline have been assigned as follows: Physics--Atomic Physics, Nuclear Science, Space Radiation, Radiation Transport and Shielding and Instrumentation: Biology--Molecular Biology, Cellular Radiation Biology, Tissue, Organs and Organisms, Radioprotectants and Plants: Risk Assessment--Radiation Health and Epidemiology, Space Flight Radiation Health Physics, Inter- and Intraspecies Extrapolation and Radiation Limits and Standards; and Microgravity. When applicable subareas have been assigned for selected topic areas. Keywords and author indices are provided.

Space Radiation Cancer Risk Projections for Exploration Missions: Uncertainty Reduction and Mitigation

The Space Radiation Guide is intended to be a reliable, easily understood handbook that will provide the reader with sufficient knowledge of the nature of space radiations to permit him to comprehend the total space radiation problem as it pertains to the hazards of manned space flight. The report is not intended to provide answers to all the problems, but, instead, to present much of the factual data currently known and to point out areas where information is sketchy and inconclusive. The radiations considered are cosmic rays, solar radiation, and the geomagnetically trapped (Van Allen) radiations. Included are chapters on instruments used for measuring these radiations, on shielding techniques, and on biological effects. (Author).

Radiation Health Research, 1986-1990

The Workshop on Decadal Science Strategy Surveys was held on November 14-16, 2006, to promote discussions of the use of National Research Council (NRC) decadal surveys for developing and implementing scientific priorities, to review lessons learned from the most recent surveys, and to identify potential approaches for future surveys that can enhance their realism, utility, and endurance. The workshop involved approximately 60 participants from academia, industry, government, and the NRC. This report summarizes the workshop presentations, panel discussions, and general discussions on the use of decadal surveys for developing and implementing scientific priorities in astronomy and astrophysics, planetary science, solar and space physics, and Earth science. Decadal Science Strategy Surveys: Report of a Workshop summarizes the evnts of the three day workshop.

Space Radiation Guide

\"This symposium was organized to bring together the multidisciplinary expertise required to assess risk of exposure to space radiation.... Topics addressed ranged from what is known or predicted about radiation environments for human exploration, and what shielding would be required based on ALARA radiation protection guidelines. The development of new physics cross section models, and improved ion beam transport codes was reported, as well as biological demonstrations of the consequences of specific shielding materials and applications to manned missions to Mars and beyond. Advancements in the biological measurements of radiation-induced protein expression profiles, membrane damage, bystander effect, and adaptive response were presented, and countermeasures evaluated. Finally several presentations addressed specific approaches to integrate the physical and biological parameters in order to assess key elements of the risk and the associated uncertainties.\"--Page 1277.

Decadal Science Strategy Surveys

Scientific, unmanned spacecraft on missions to Jupiter and beyond will be subjected to nuclear radiation from the natural environment and onboard nuclear power sources which may be harmful to subsystems. This report postulates these environments and discusses practical considerations to ensure confidence that the spacecraft's materials and subsystems will withstand the effects of anticipated radiation. Degradation mechanisms are discussed.

NCRP Report

This document addresses calculations of probability distribution functions (PDFs) representing uncertainties in projecting fatal cancer risk from galactic cosmic rays (GCR) and solar particle events (SPEs). PDFs are used to test the effectiveness of potential radiation shielding approaches. Monte-Carlo techniques are used to propagate uncertainties in risk coefficients determined from epidemiology data, dose and dose-rate reduction factors, quality factors, and physics models of radiation environments. Competing mortality risks and functional correlations in radiation quality factor uncertainties are treated in the calculations. The cancer risk

uncertainty is about four-fold for lunar and Mars mission risk projections. For short-stay lunar missins (180 d) lunar or Mars missions, GCR risks may exceed radiation risk limits. While shielding materials are marginally effective in reducing GCR cancer risks because of the penetrating nature of GCR and secondary radiation produced in tissue by relativisitc particles, polyethylene or carbon composite shielding cannot be shown to significantly reduce risk compared to aluminum shielding. Therefore, improving our knowledge of space radiobiology to narrow uncertainties that lead to wide PDFs is the best approach to ensure radiation protection goals are met for space exploration.Cucinotta, Francis A. and Kim, Myung-Hee Y. and Ren, LeiJohnson Space CenterBIOASTRONAUTICS; RADIOBIOLOGY; RADIATION DOSAGE; PROBABILITY DISTRIBUTION FUNCTIONS; CANCER; RADIATION HAZARDS; ASTRONAUTS; LUNAR EXPLORATION; MARS EXPLORATION; MANNED MARS MISSIONS; LONG DURATION SPACE FLIGHT; MANNED SPACE FLIGHT; RISK; RADIATION SHIELDING; MONTE CARLO METHOD

Radiobiological Factors in Manned Space Flight

Radiation protection problems on earth and in space are discussed. Methods applied to evaluate and control or avoid the various Apollo radiation hazards are discussed.

Space Radiation Guide

Examination Thesis from the year 2009 in the subject Physics - Electrodynamics, The University of Surrey, course: Electronic Engineering, language: English, abstract: The Space radiation environment in GEO has always been a severe challenge to the spacecraft industry. The Spacecraft Environment interaction has been the topic of deep investigation since 1970s to onwards. Very harsh space environment affects the spacecraft in various ways. The current project presents an overview of the characteristics of space radiation environment, its effects on spacecraft electronics and spacecraft operations. The elements of the space radiation environment such as Galactic Cosmic Rays (GCRs), Solar flare protons and trapped electron belt in GEO are explained comprehensively. The effects of hazardous space radiation environment on a GEO spacecraft including spacecraft charging, Total Ionizing Dose (TID), internal charging and Single Event Effects (SEE) are introduced with necessary details. The space radiation environment models currently available are critically analysed and explained in the light of the work of different space researchers. The limitations and risks involved with these models are briefly introduced. The spacecraft design mitigation techniques and design guidelines are presented to help the spacecraft community build the spacecraft capable of surviving in hazardous radiation environment. Then some case studies of GEO satellite anomalies are also briefly explained. The ESA based Space Environment Information System (SPENVIS) software package is utilized for analyzing the temporal, spatial and diurnal variations of radiation environment in geostationary orbit and the simulation results are compared with GOES data. A detailed space radiation environment analysis for a Pakistani geostationary communication satellite Paksat-1R has been undertaken including the trapped electron flux estimation, solar proton flux estimation, Solar cell degradation and cover glass require

Space Life Sciences

This report has considered the scientific bases needed to formulate models and define model parameters for an assessment of the risks to the general population and the environment from space applications of Pu-239. As such the following topical areas have been critically reviewed: the physical and chemical properties of Pu-238 oxides; environmental transport of released Pu-238 and Pu-239 in the atmosphere, hydrosphere and lithosphere; metabolism and biokinetics of inhaled, ingested and transcutaneously absorbed Pu-238 and Pu-239 in man and experimental animals; experimental data on health effects from exposure to Pu-238; and epidemiological evidence of health effects from exposure to Pu-238 and Pu-239, and human health risk factors.

Fluence-based and Microdosimetric Event-based Methods for Radiation Protection in Space

In this paper we discuss expected lifetime excess cancer risks for astronauts returning from exploration class missions. For the first time we make a quantitative assessment of uncertainties in cancer risk projections for space radiation exposures. Late effects from the high charge and energy (HZE) ions present in the galactic cosmic rays including cancer and the poorly understood risks to the central nervous system constitute the major risks. Methods used to project risk in low Earth orbit are seen as highly uncertain for projecting risks on exploration missions because of the limited radiobiology data available for estimating HZE ion risks. Cancer risk projections are described as a product of many biological and physical factors, each of which has a differential range of uncertainty due to lack of data and knowledge. Monte-Carlo sampling from subjective error distributions represents the lack of knowledge in each factor to quantify risk projection overall uncertainty. Cancer risk analysis is applied to several exploration mission scenarios. At solar minimum, the number of days in space where career risk of less than the limiting 3% excess cancer mortality can be assured at a 95% confidence level is found to be only of the order of 100 days.Cucinotta, Francis and Badhwar, Gautam and Saganti, Premkumar and Schimmerling, Walter and Wilson, John and Peterson, Leif and Dicello, JohnJohnson Space Center; Langley Research CenterASTRONAUTS; CANCER; GALACTIC COSMIC RAYS; RISK; SPACE EXPLORATION; PLANETARY ENVIRONMENTS; RADIATION HAZARDS; CONFIDENCE LIMITS; LOW EARTH ORBITS; MONTE CARLO METHOD; RADIOBIOLOGY; RADIATION DOSAGE; MORTALITY; IONS; SPACE MISSIONS; MANNED SPACE FLIGHT

Radiation Hazards to Crews of Interplanetary Missions

\"This Report has been prepared at the request of the National Aeronautics and Space Administration (NASA). It is the second phase of a two-phase effort intended to provide guidance to NASA concerning the health effects and mission impacts of space radiation exposure on the central nervous system (CNS) of crew members. The first phase of effort resulted in the National Council on Radiation Protection and Measurements (NCRP) Commentary No. 25, Potential for Central Nervous System Effects from Radiation Exposure During Space Activities. Phase I: Overview, which described the critical issues surrounding the potential short- and long-term consequences of space radiation on the CNS and laid the groundwork for a more comprehensive investigation that is the basis of this Report. This Report summarizes the steps and approaches needed to more fully understand the risk of CNS effects following radiation exposures in space and provides guidance for radiation protection, including risk management. NCRP has identified knowledge gaps regarding the implementation of a comprehensive and effective radiation safety program to protect astronauts against the potential for early and late CNS effects from space radiation\"--

Space Radiation Effects on Materials

Subsystem Radiation Susceptibility Analysis for Deep-space Missions