

12. Conclusion Space radiation is one of the major challenges facing long-duration human missions to Mars. On Earth, the atmosphere and magnetic field provide natural protection. In deep space, astronauts must rely much more heavily on spacecraft design, shielding, monitoring, and operational strategies. The main radiation sources include galactic cosmic rays and energetic solar particles. Their effects depend on radiation type, particle energy, dose, dose rate, and exposure duration. The concepts of absorbed dose and equivalent dose are therefore essential for evaluating astronaut exposure. Measurements from NASA's Radiation Assessment Detector on Curiosity have demonstrated that the Martian surface has a measurable radiation environment. These observations provide valuable data for future mission planning and show why radiation cannot be treated as a theoretical issue. Radiation shielding is also more complicated than simply increasing wall thickness. Added shielding increases spacecraft mass, while interactions between high-energy particles and shielding materials can generate secondary radiation. Future protection systems will therefore need optimized materials, intelligent spacecraft layouts, dedicated shelters, monitoring systems, and improved space-weather forecasting. Ultimately, radiation does not make human exploration of Mars impossible, but it represents a serious scientific and engineering challenge. Continued research in radiation physics, materials science, spacecraft engineering, and space medicine can help reduce exposure and make future deep-space missions safer and more achievable.