# Practical Applications of Cosmic Ray Science: Spacecraft, Aircraft, Ground-Based Computation and Control Systems, Exploration, and Human Health and Safety

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In this presentation a review galactic cosmic ray (GCR) effects on microelectronic systems and human health and safety is given. The methods used to evaluate and mitigate unwanted cosmic ray effects in ground-based, atmospheric flight, and space flight environments are also reviewed. However not all GCR effects are undesirable. We will also briefly review how observation and analysis of GCR interactions with planetary atmospheres and surfaces and reveal important compositional and geophysical data on earth and elsewhere.

About 1000 GCR particles enter every square meter of Earth's upper atmosphere every second, roughly the same number striking every square meter of the International Space Station (ISS) and every other low- Earth orbit spacecraft. GCR particles are high energy ionized atomic nuclei (90% protons, 9% alpha particles, 1% heavier nuclei) traveling very close to the speed of light. The GCR particle flux is even higher in interplanetary space because the geomagnetic field provides some limited magnetic shielding. Collisions of GCR particles with atomic nuclei in planetary atmospheres and/or regolith as well as spacecraft materials produce nuclear reactions and energetic/highly penetrating secondary particle showers.

Three twentieth century technology developments have driven an ongoing evolution of basic cosmic ray science into a set of practical engineering tools needed to design, test, and verify the safety and reliability of modern complex technological systems and assess effects on human health and safety effects. The key technology developments are: 1) high altitude commercial and military aircraft; 2) manned and unmanned spacecraft; and 3) increasingly complex and sensitive solid state micro-electronics systems. Space and geophysical exploration needs drove the development of the instruments and analytical tools needed to recover compositional and structural data from GCR induced nuclear reactions and secondary particle showers. Finally, the possible role of GCR secondary particle showers in addressing an important homeland security problem, finding nuclear contraband and weapons, will be briefly reviewed.