Máster Universitario en Ingeniería Aeronáutica

The Space Environment

Overview of space environment effects

POLITÉCNICA

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The Earth's space environment

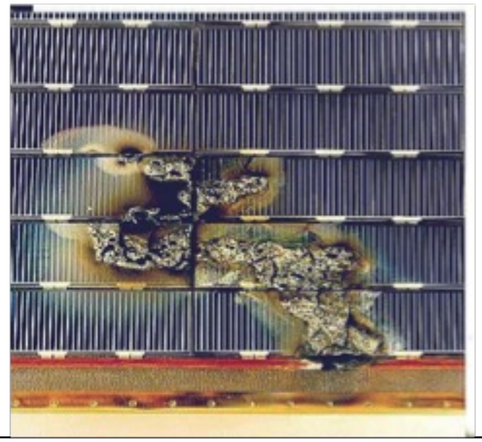
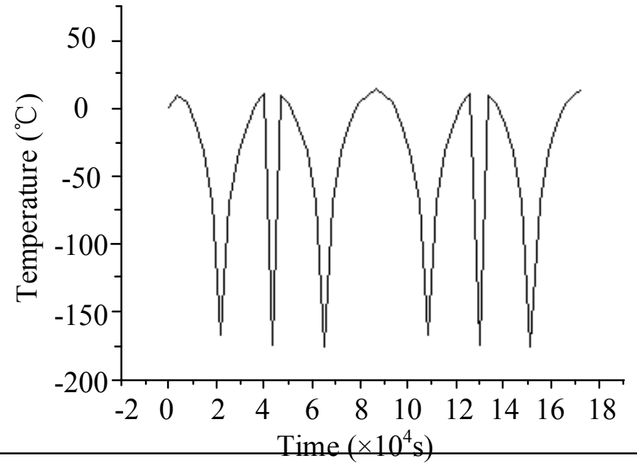
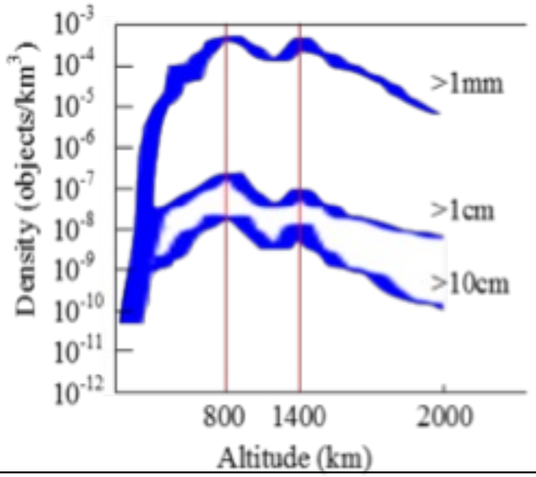
- Both spacecrafts and their environment are active media: vehicles emit neutral gas, particles, EM radiation, … and interact with its surroundings. We can say,

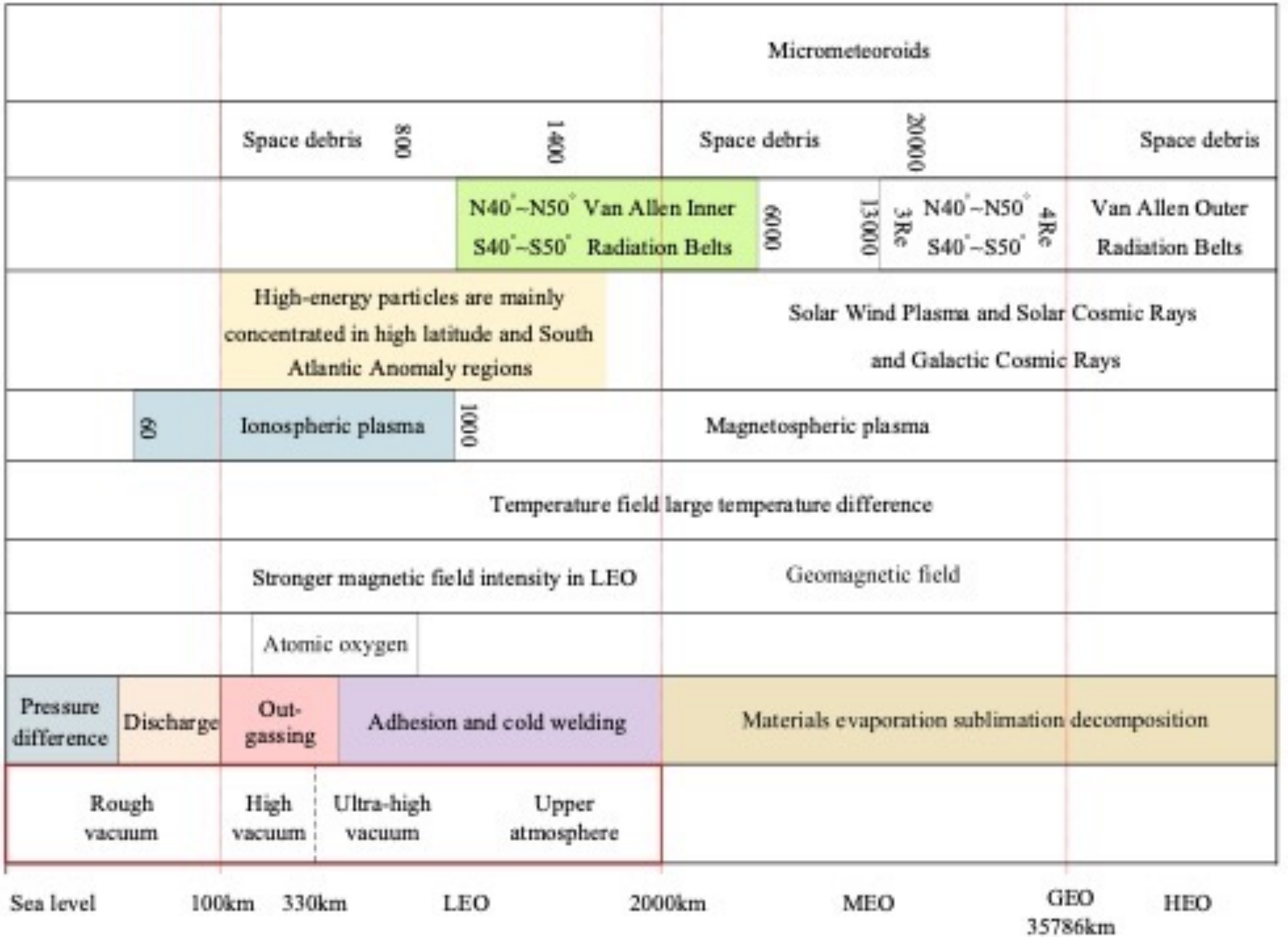
  The environment to which a spacecraft is subjected consists of a combination of the ambient (typically a function of the orbit) and that generated by the spacecraft itself. The combination of both can give rise to synergic deleterious effects on the vehicle.

- In addition to solar activity, the conditions in which the vehicle operates in Earth orbit is basically determined by the following elements,

Neutral gas	Neutral gas with variable chemical composition which depends on the altitude in addition to outgassing and/or gas from thruster firings.
Plasmas	The plasmas at the ionosphere, magnetosphere have different chemical composition and physical characteristics.
EM radiation	X-ray, UV radiation from the Sun produce electron emission form surfaces. Thermal effects by day/night cycle radiation.
Energetic particles	Energetic particles from Van Allen radiation belts and/or high energy particles from the solar wind.
Solid Particles / objects	Micrometeoroids and space debris is present in Earth orbits.

Overview of Space Environment Effects

Neutral gas	Plasmas	Radiation	Solid particles
• Orbital drag. • Cold welding. • Glow. • Surface contamination. • Sublimation of materials	• Surface charging and/or vehicle charging. • Short circuits. • Material performance degradation. • Erosion in LEO by interaction with atomic oxygen. • High altitude electric discharges.	• Interaction with particles trapped on the Van Allen belts. • EM radiation from the Sun. • Thermal effects. • EM interference.	• Orbiting debris. • Particles ejected. • Micrometeoroids. Large $L > 10$ cm Medium 10 cm $> L > 10$ cm Small $L < 10$ cm
			
ISS solar array blanket after one year in LEO showing the oxidation of underlying Kapton.	Sustained arc damage from the ESA *Eureca* mission .	Cyclic thermal conditions with the sun/shadow transition in GEO orbit.	Macroscopic particle distribution in LEO


Micrometeoroids
Space debris
800
1400
Space debris
20000
Space debris
N40°~N50°
S40°~S50°
Van Allen Inner Radiation Belts
6000
13000
3Re
N40°~N50°
S40°~S50°
4Re
Van Allen Outer Radiation Belts
High-energy particles are mainly concentrated in high latitude and South Atlantic Anomaly regions
Solar Wind Plasma and Solar Cosmic Rays and Galactic Cosmic Rays
80
Ionospheric plasma
1000
Magnetospheric plasma
Temperature field large temperature difference
Stronger magnetic field intensity in LEO
Geomagnetic field
Atomic oxygen
Pressure difference
Discharge
Out-gassing
Adhesion and cold welding
Materials evaporation sublimation decomposition
Rough vacuum
High vacuum
Ultra-high vacuum
Upper atmosphere
Sea level
100km
330km
LEO
2000km
MEO
GEO
35786km
HEO