PHOTOVOLTAICS IN SPACE APPLICATIONS

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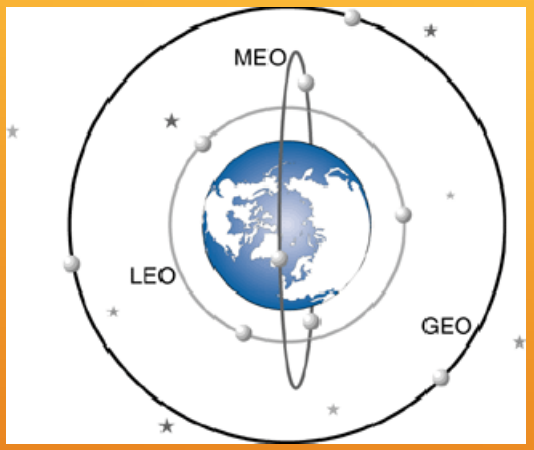
HISTORY

- March 17th ,1958- Vanguard I
  - 1st satellite to be powered photovoltaics (Provided ~ 1W)
  - Solar Cells lasted ~7 yrs while the batteries lasted 20 days
- August 7, 1959 – Explorer VI
  - 15W array
- August 28th 1964 – Nimbus 1
  - 470W array
  - Later Nimbus program satellite had 1st Sun tracking arrays
- November 20, 1998
  - 262,400 solar cells
    - Can provide 120 kW

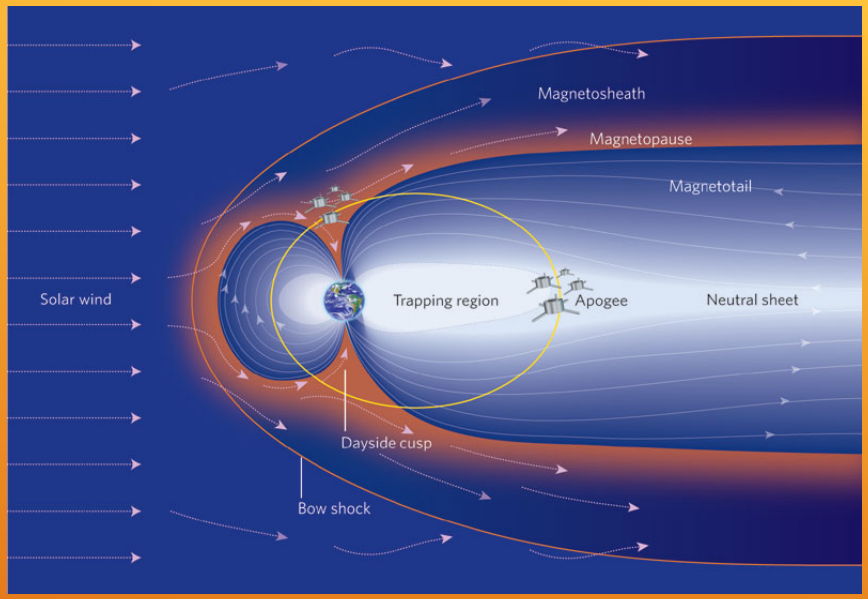
SPACE ENVIRONMENT

- 3 Environments Satellites normally see
  - Low Earth Orbit (LEO) – altitude of 160 – 2000 km
  - Geosynchronous Earth Orbit (GEO) – orbital period = Earth's rotational period
  - Mid Earth Orbit (MEO) – above Leo, but below 35,786 km
- Solar Wind –stream of charged particles from Sun
  - As fast as 900 km/s
  - Electrons with energy up to 10 keV



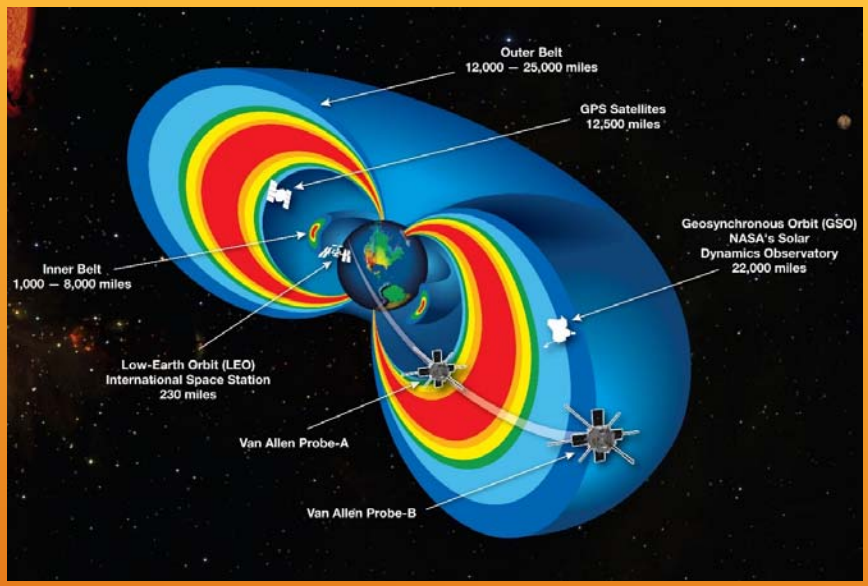
LEO VS EARTH

- Average Atmospheric temperature ~1000K
- High radiation damage at poles
  - Points where Magnetosphere is weakest
- **Experiences roughly 6000 thermal cycles per yr**
  - **Moving in and out of Earth's shadow**



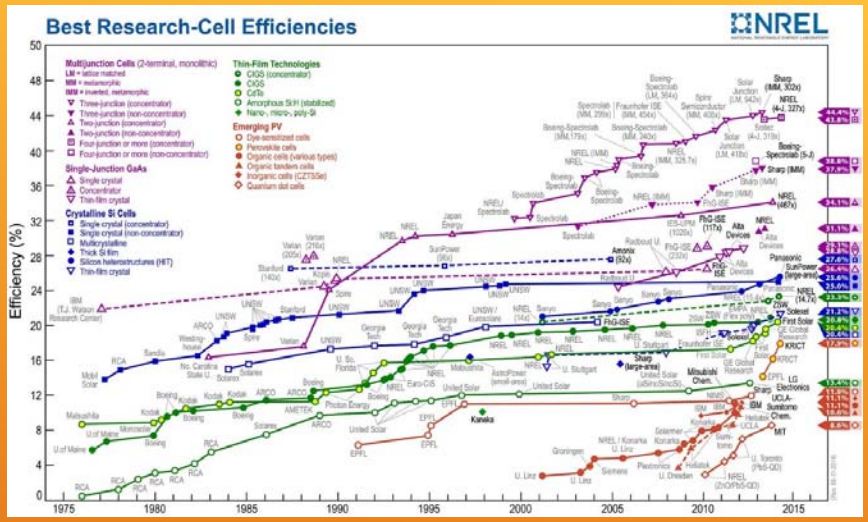
GEO

- Radiation source of most damage
  - Lack of protection from Earth's atmosphere
- Solar Flares are also a concern
  - A single solar flare can lead to degradation equal to one year



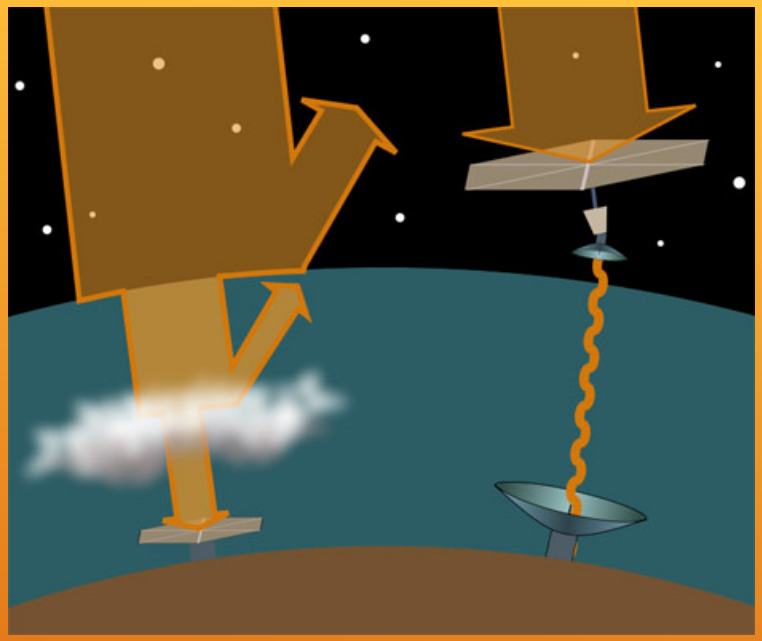
CURRENT STATE OF THE ART

- Triple Junction solar cell with ~30 % efficiency
  - GaInPx/GaAs/Ge
- Made using Metal Organic Vapor Phase Epitaxy
- Costs from $250/W - $400/W
  - First Solar Solar CdTe panels cost ~$0.59/W
  - Cost ~$20,000/lb to get into space



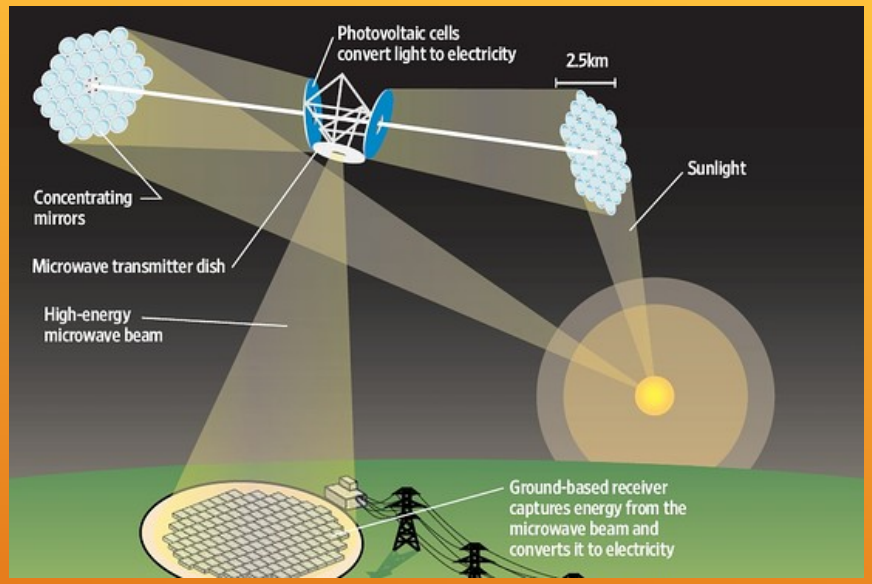
SPACE-BASED SOLAR POWER

- Roughly 30% of solar energy never reaches Earth
  - Atmosphere
  - Earth's Tilt
  - Sun is not always shining on Earth
- Solution: Launch-self assembling satellites into space that beam power back to Earth
  - Microwave or Laser Transmitting



MICROWAVE TRANSMISSION

- Satellites are launched to GEO
- Each solar reflector is extremely large
  - Diameter of 3km
  - Weight over 80,00 metric tons
- Would require 40 launches for all material to reach space
  - Single satellite would cost tens of billions



LASER TRANSMISSION SATELLITES

- Satellites are launched to LEO
- Only weighs 10 metric tons
- Would cost roughly $500 million per satellite
  - Low capacity (1 – 10 MW) so many satellites would be needed

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