Earth-Moon-Earth Communications as an Analog to Earth Mars Communications

GES - 8/2002

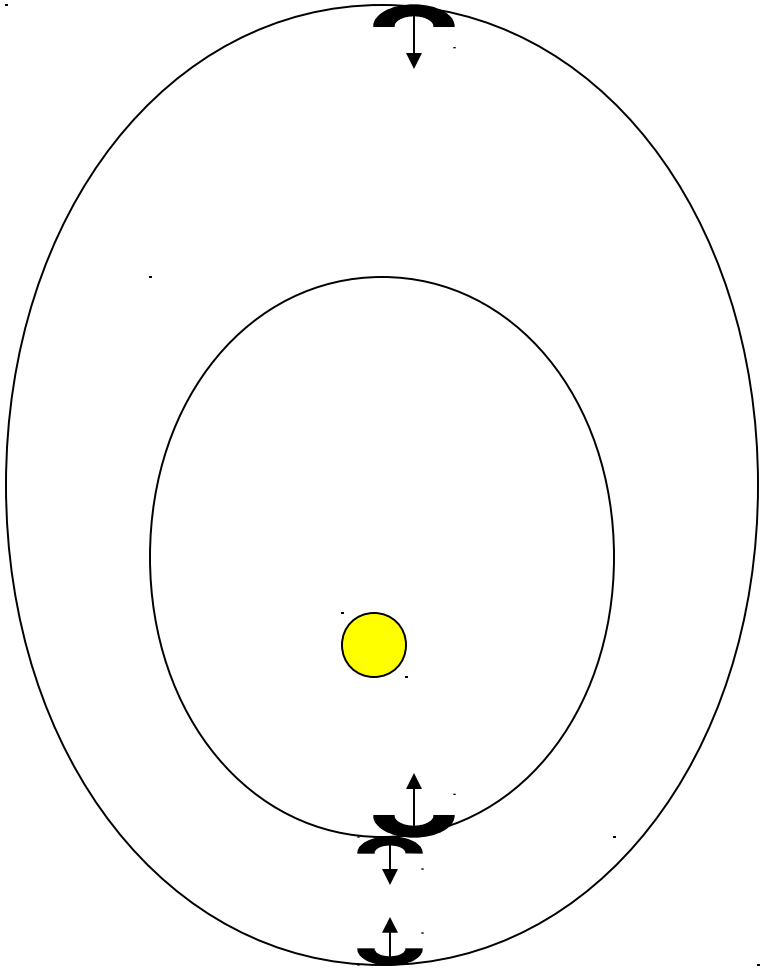
Project Justifications

- Public Outreach
  - Amature Radio
  - Hab Support
- Support Government Mars Exploration
  - DSN Relief
- Exploration on a Private Basis.
  - Infrastructure Development

Availability

- Earth-Moon-Earth
  - 1/2 Terrestrial Day
  - limits
    - Local Terrain
    - Antenna Beamwidth
  - Solar eclipses
  - Common View
- Earth-Mars
- Receiving
  - Same as EME
  - Multiple Stations
- Transmitting
  - 1/2 Martian Day
- Solar Conjunction

Earth Mars Distances



- Minimum Distance
  - 54.6E6km (.4 AU)
- Maximum Distance
  - 401E6 (2.7 AU)
  - Blocked by Sun
- Relay Sats ?

Free Space Path Loss

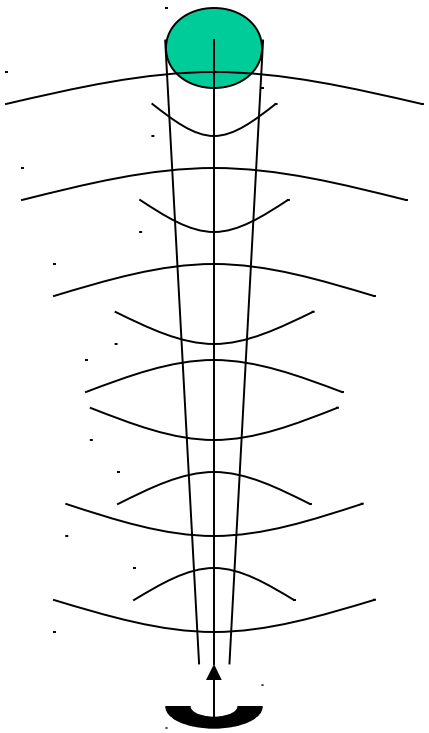
- Power Flux Density = Power/$4\pi Range^2$
- Antenna Gain = $4\pi Area/\lambda^2$
- Received Power = $Power[\lambda/4\pi Range]^2$
- Path Loss = 20 Log $(\lambda/4\pi Range)$
  - Inversely Proportional to $Range^2$
  - Frequency Dependant from Antenna Size
- ERP = Effective Radiated Power

Earth Mars Path Loss

- Assume at 300MHz (1 meter λ)
- Minimum Loss of 236 dB
- Maximum Loss of 254 dB

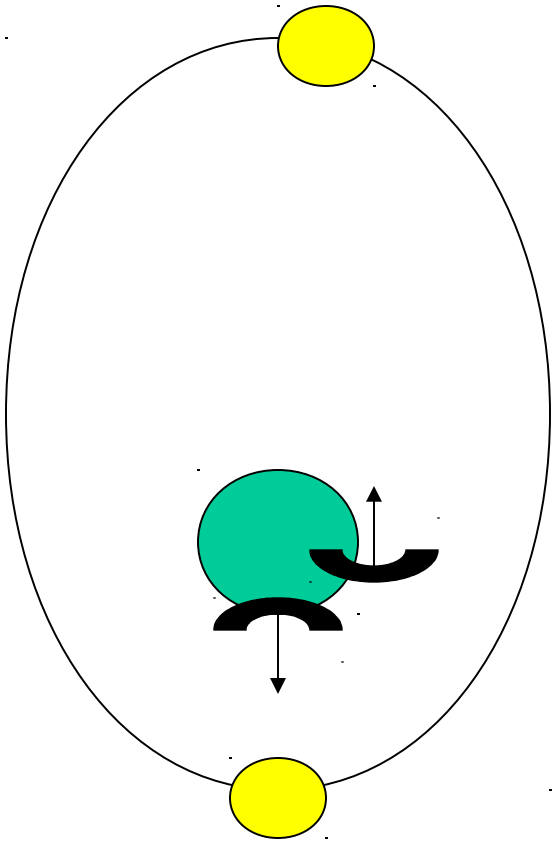
- eg 1watt in = $1/10^{24}$ Watts out

Radar Path Loss



- Lunar Aperture = $4\pi D^2$
- Return Path loss
- Radar Received Power =
  - Power$[D\lambda/16\pi Range^2]^2$
- Path Loss Inversly Proportional to Range^4
- Sm Beam Inversly Proportional to Range^2

Earth Moon Distances



- Minimum distance
  - 350000km
- Maximum Distance
  - 407000 km
- Paths are 2x
- Time delay =
  - Min = 2.33 sec
  - Max = 2.72 sec

EME Radar Path Loss

- Assume at 300MHz (1 meter λ)
- Assuming >0.5 deg Beamwidth (<140m)
  - Minimum Loss of 245 dB
  - Maximum Loss of 248 dB

- Actual loss 259dB

EME Simple Path Loss

- Assume at 300MHz (1 meter λ)
- Assuming < 0.5 deg Beamwidth
  - Minimum Loss of 202dB
  - Maximum Loss of 203dB
- Additional Reflection Loss
  - 13dB at UHF
  - Material, Terrain, Libration Fading

EM - EME Comparison

- Earth - Mars
  - 236 to 254 dB
  - 245 +/-9 dB
- Earth - Moon - Earth
  - 216 or 259 +/- 1 dB

  - (300MHz)

440 MHz System Capabilities

- 5m Dish , 1500W power
  - Beamwidth 9.5 deg
  - Data Rate
- 5 & 20m Dishes
  - 20m Beamwidth 2.3 deg
  - Data Rate
- Optional Yagi Array

440 MHz System Costs

- UHF Transceiver Kit $400.00
- LunarLink Amp
  - 1500W Amp $1580.00
  - Tubes(2) $ 870.00
  - Power Supply $ 860.00
  - Relay $ 230.00
- LNA $140.00
- Dish Feeds $ 30.00

10GHz System Capabilities

- 5m Dish , 2W power
  - Beamwidth 0.4 deg
  - Data Rate
- 5+20m Dishes
  - 20m Beamwidth 0.10deg
  - Data Rate

10GHz System Costs

- DPS-10 VHF Transceiver Kit $400.00
- DEMI transverter A&T $915.00
  - 2W Output power
  - <1 dBNF input
  - 144 MHz IF fre
- Dish Feeds $150

Antennas

- 1,2,3,5 m TVRO Dishes
- 20m DSES Dishes
- Homebrew Antenna Feeds
- Motorized Mounts
- Magnetic/Acceleration Sensors
- Digital Control Systems