Guglielmo Marconi Orbiter – The First Interplanetary Communications Satellite

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Overview

- Mars Relay Network
- Relay Users
- Guglielmo Marconi Orbiter (GMO) Mission Design
- End-to-End Information System Design
- Mission Operations
Mars Relay Network

- Relay communications
  - Range$^2$ reduced by a factor of up to $6.4 \times 10^{21}$ (218 dB)
  - Gigantic improvement in ability to communicate with in-situ elements
- UHF relay radios added to most Mars science orbiters
  - Now orbiting Mars: NASA Mars Global Surveyor & Mars Odyssey
  - 2003 ESA Mars Express, 2005 NASA Mars Reconnaissance Orbiter, 2007 CNES Premier Orbiter
  - Relay performance limited by primary science mission
    - Low orbit optimized for science, not relay
    - Omnidirectional relay antenna on shared platform
- Guglielmo Marconi Orbiter
  - High orbit optimized for relay service
  - High performance steered relay antennas
High Relay Orbit
Increases Contact Time

Orbit optimized for data volume, contact time and Entry, Descent & Landing (EDL) support rather than for science observations.

High orbit → EDL tracking for wide range of landing sites, long contact times
Long contact times → operational flexibility, traverse monitoring
High orbit maximizes area of Mars in view, maximizing possible landing site locations.

GMO orbit node can be selected to facilitate EDL tracking.
Increased Data Return

High orbit + X-band = huge increase in data return

Data Volume (Large Rover)

Gb/Sol

MRO  PREMIER  GMO 4450  GMO ACE

UHF  X-Band
Relay Users

- 2003 (before GMO)
  - 2 NASA Mars Exploration Rovers
  - British Beagle II

- 2007
  - European (CNES) NetLanders
  - NASA Mars Scout

- 2009
  - NASA Mobile Science Laboratory (MSL)

- 2011 & Beyond
  - NASA Mars Scout
  - NASA Mars Sample Return

October 10, 2002
GMO Mission Design

- Launch in 2007
- Type II trajectory to Mars
- Orbit Options
  - Circular sun synchronous
    - 4450 km
    - 1000 km
  - Elliptical
    - \( \frac{1}{2} \) sol Apoapsis at Constant time-of-day Equatorial (ACE)
    - \( \frac{1}{4} \) sol Apoapsis at Constant time-of-day Critically Inclined
Mars Relay Network End-to-End Information System

- Electra relay radio will be carried by all Mars orbiters beginning with NASA Mars Reconnaissance Orbiter in 2005
- Break between 2003 and 2007 landers being used to develop new end-to-end information system with greater commonality

Objectives
- Make orbiter & ground system transparent to relay user
- Share development costs
1) GDS receives Binary File from Relay User Ops via FTP
2) GDS segments Binary File into CFDP PDUs optimized for the relay link
3) GDS encapsulates CFDP PDUs into Command Link Transmission Unit (CLTU)
4) Ground station transmits CLTU to GMO
5) GMO SFC extracts CFDP PDUs from CLTU
6) GMO SFC reconstructs Binary File from CFDP PDUs
7) GMO SFC segments Binary File into new CFDP PDUs optimized for the relay link & stores in memory
8) Electra relays CFDP PDUs to Asset using Proximity-1
   - Full duplex using Reliable Bit Stream
   - Half Duplex using Reliable CFDP
9) Asset assembles Binary File from CFDP PDUs