Mars Express science planning and operations and their accuracy

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Basic MEX operations parameters: Orbit

- **Around Mars**
  - highly elliptical, polar
  - period 6.75 h
  - 3:11 ground track resonance
  - 2.5 x latitude coverage
  - full seasonal coverage
- **Mars/MEX - Earth - Sun**
  - day/night observations 60% day, 40% night
  - data rate (for 35m) 0.8 to 5.2 Gb @ 8h/day
  - power 500 to 730W
  - long eclipses: 3 phases max. 90 min

Figure 7.1: Shape of Orbits G3-u and G3-b

- Around Mars
  - highly elliptical, polar
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Illumination Conditions over 2 Mars years

30 deg true anomaly
≈ 450 km altitude

Basic MEX operations parameters: Sharing of day/night
Basic MEX operations parameters: S/C and mission design

- **S/C**
  - 3-axis stabilized, slews <0.15 deg/s
  - for normal conditions (eclipses < 40 min): 1x nadir + 1x inertial ptg per orbit
  - however, restrictions due 70% power problem for eclipses > 40 min
  - downlink: nearly 24/7 coverage NNO (35 m) + DSN
  - up/downlink: 1x 4h contiguous link/day + (4+X)h/day

- **Mission**
  - nominal mission: 1 Mars year=2440 orbits, 706 mission days
  - no 2 orbits cover the same surface point under the same conditions (illumination, time distance from pericenter, distances to Earth and Sun)
MEX downlink

- NNO 35m
- DSN 35m/70m
  - ✤ flexibility for up/downlink
  - ✤ data volume
Instrument operation requests

- Instrument objectives lead to highly diverse operation requests with respect to:
  - type, position and duration of science pointings
  - periodicity of observations

- Sharing of resources:
  - near pericenter prime time
  - number and type of science pointings
  - downlink volume, memory capacity
  - on-board bus data rate
Instrument requests: illumination and altitude

day-light observations

Omega global
Omega high
PFS
Spicam
HRSC

Aspera
MaRS
Marsis

high altitudes
low altitudes

night-time observations
Instrument requests: pointing and observations periodicity

- Spicam
- Marsis
- Omega
- HRSC
- Aspera
- MaRS
- PFS
Instrument requests and S/C constraints
Science planning: constraints

- objective
  - fulfill mission science goals
  - optimum use of resources

- science objectives
- illum., power etc. constraints

- spacecraft
  - mid-term planning for 1 month with 2 months lead time
  - highly accurate orbit maintenance (optimized reaction wheel off-loading)
  - highly accurate science pointings
  - validation of power/thermal models during routine phase

- ground stations
  - coordination with other planetary missions
  - updates of availability schedule may lead to late changes of a major resource

- priorities per planning period
  - science themes
  - science master plan
Science planning: 2 level process

- mid-term planning level 1: step 1
  - agreement of instrument plans using instrument mode level requests (MREQs)
  - result: pointing request file, instrument on/off times, data share plan
  - duration: 2-3 weeks
  - covered period: 4 weeks
- mid-term planning level 1: step 2
  - check/verification of requests
  - generation of S/C and ground station commands
  - duration: 4 weeks (1 iteration step)
- planning level 2: step 1
  - generation of instrument command files (PORs) 4x 1 week
  - based on instrument mode level request (MREQs)
- planning level 2: step 2
  - check+merge of instrument commands with S/C and groundstation
Science planning: level 2
### Science planning schedule

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Science planning achievements

- achievements
  - 12 MTP routine phase cycles planned
  - resources used close to maximum
  - no major hickups during Mars operations, including the 5 weeks occultation and the max. eclipse periods

- accuracy:
  - pericenter passage time predict for MTP planning: ±10 sec (spec was 2 min)
  - pointing: better than 0.01 deg = 36 arcsec = 0.175 mrad (spec was 0.05 deg)

- extra operations
  - MER-MEX communications demo passes
  - Cassini/Huygens VLBI
  - Spot pointing tests
Science planning outlook

- **problem areas**
  - on board data overflow during low data rate phases
  - long lead times
  - data gaps

- **outlook- nominal mission**
  - Marsis deployment
  - 4 new pointing modes (spot pointing with +Z and HGA, specular, rotation)
  - very high data rate phase: 70% of the nominal mission data still to come
  - eclipse phase #3
Extended mission

- resources: fuel (per bookkeeping)
  - 39.9 kg per 12/11/04
  - 2.3 kg/year
- resources: power
  - aphelion @ mission day 900
  - 22.5% battery degradation