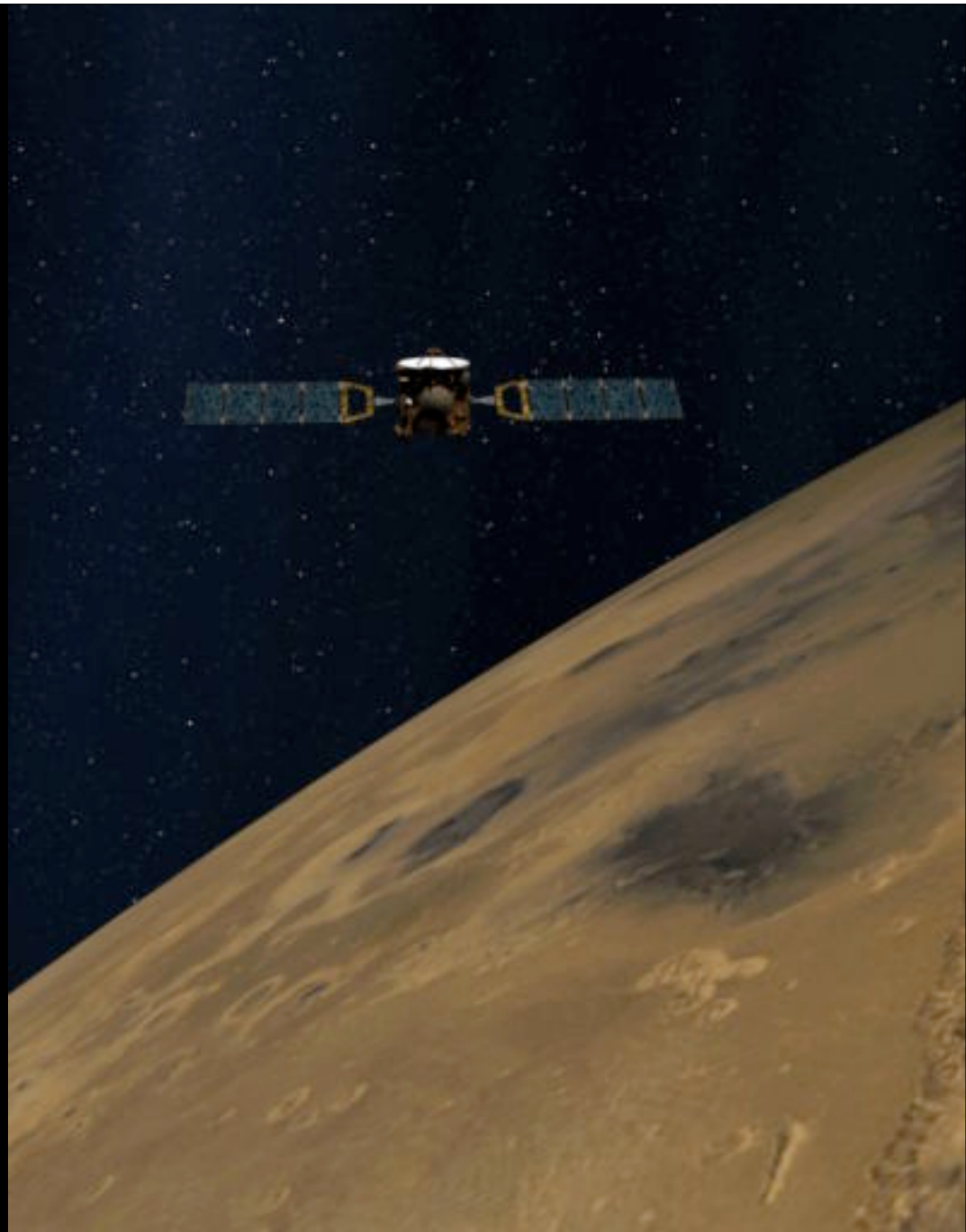


# Mars Express science planning and operations and their accuracy

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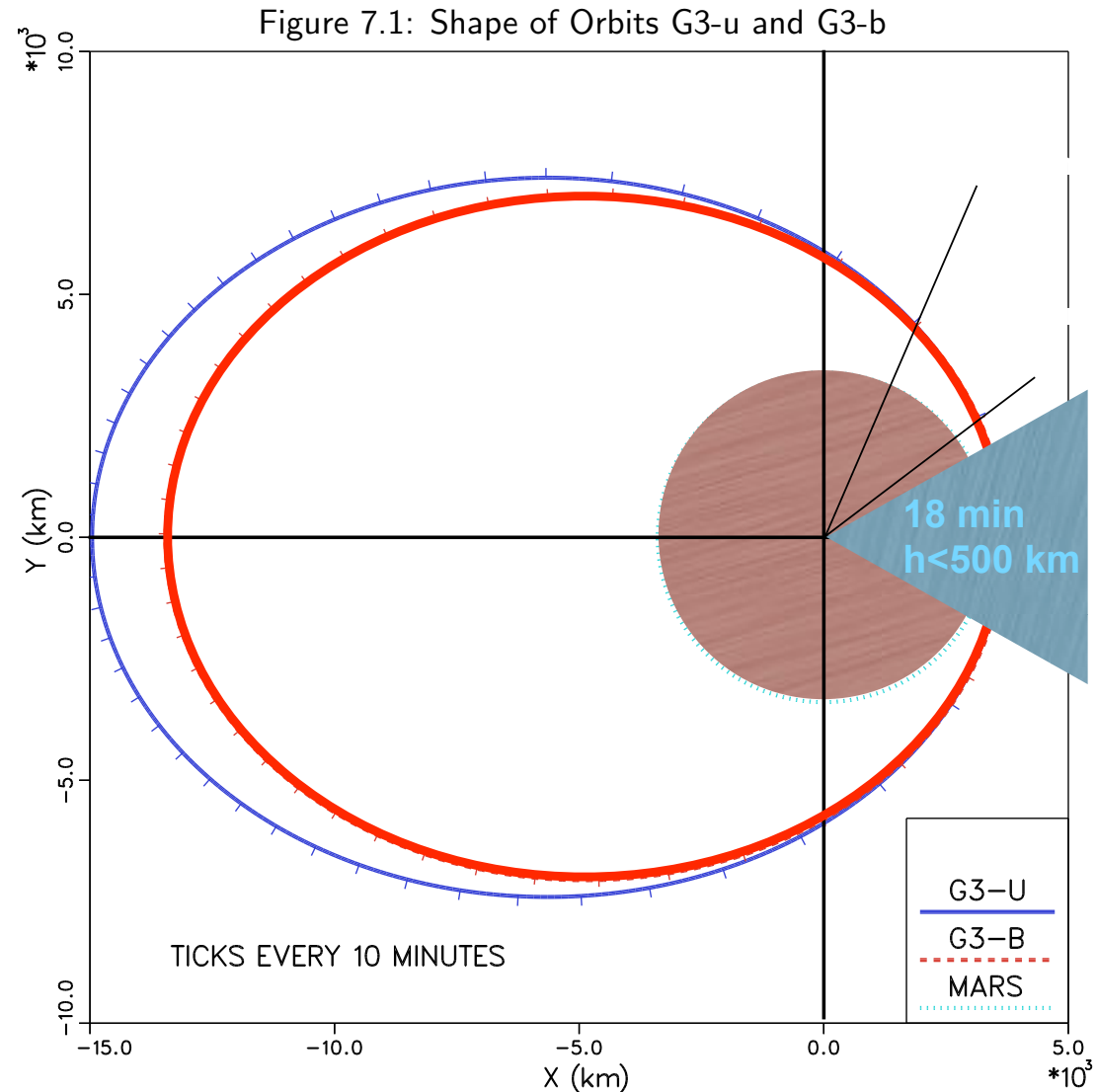


**Basic MEX operations parameters**  
**MEX Instrument requests**

**Science planning**  
**Outlook: Extended mission**

# Basic MEX operations parameters: Orbit

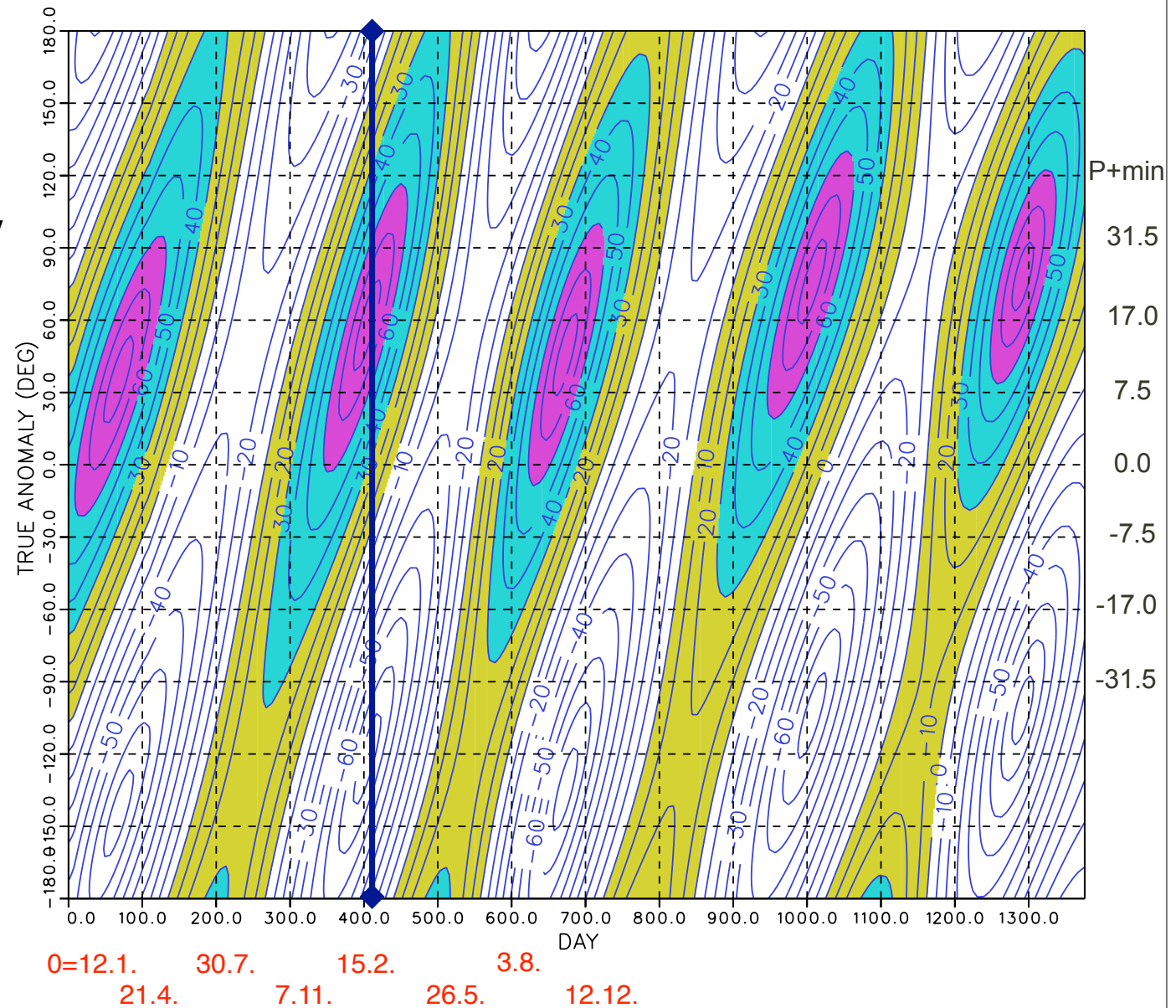
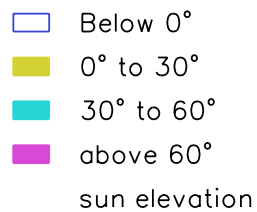
- **Around Mars**
  - highly elliptical, polar
  - period 6.75 h
  - 3:11 ground track resonance
  - 2.5 x latitude coverage
  - full seasonal coverage
- **Mars/MEX - Earth - Sun**
  - day/night observations 60% day, 40% night
  - data rate (for 35m) 0.8 to 5.2 Gb @ 8h/day
  - power 500 to 730W
  - long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



# Basic MEX operations parameters: Sharing of day/night

**Illumination  
Conditions over  
2 Mars years**

**30 deg true anomaly  
≈ 450 km altitude**

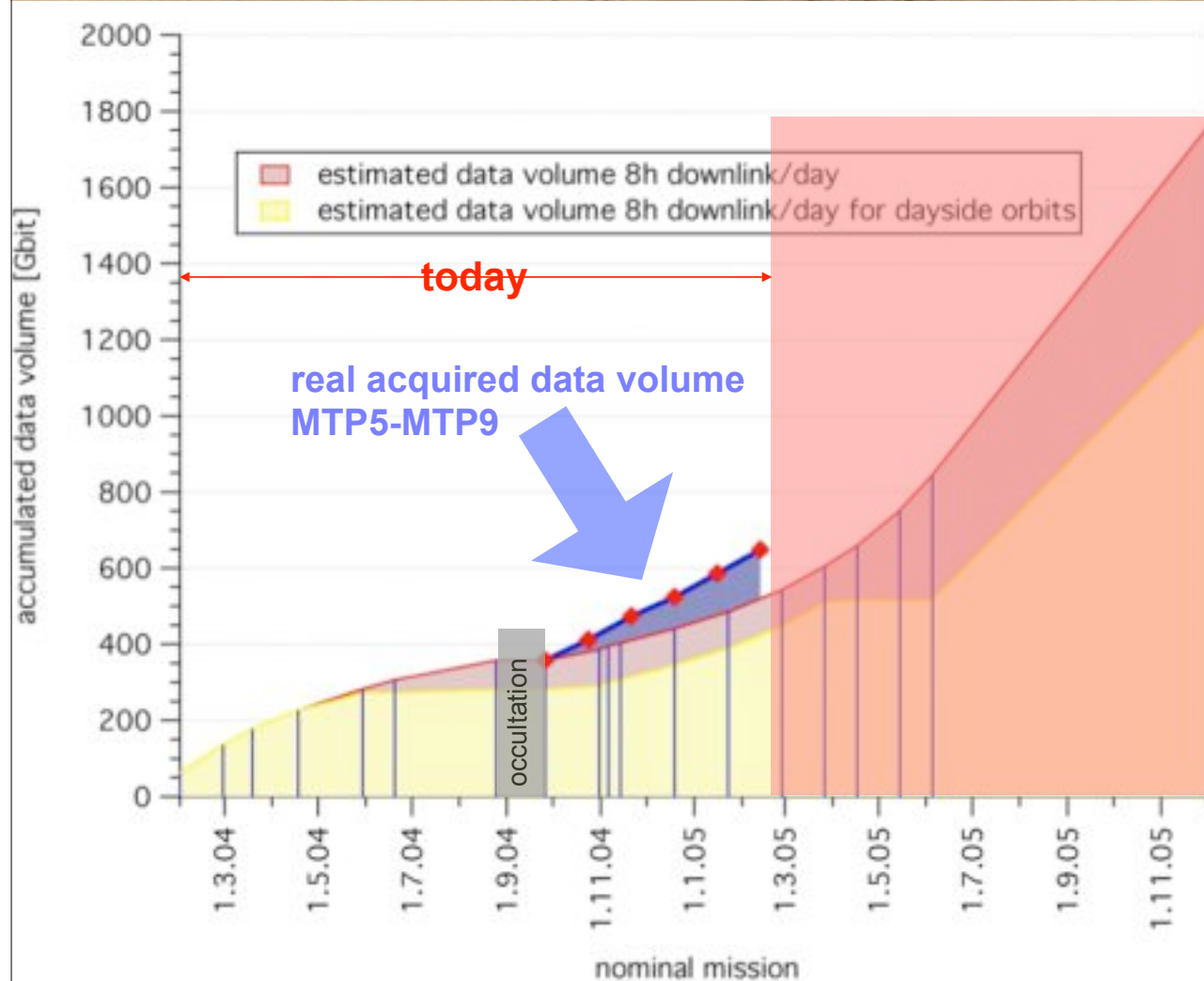


## Basic MEX operations parameters: S/C and mission design

- **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



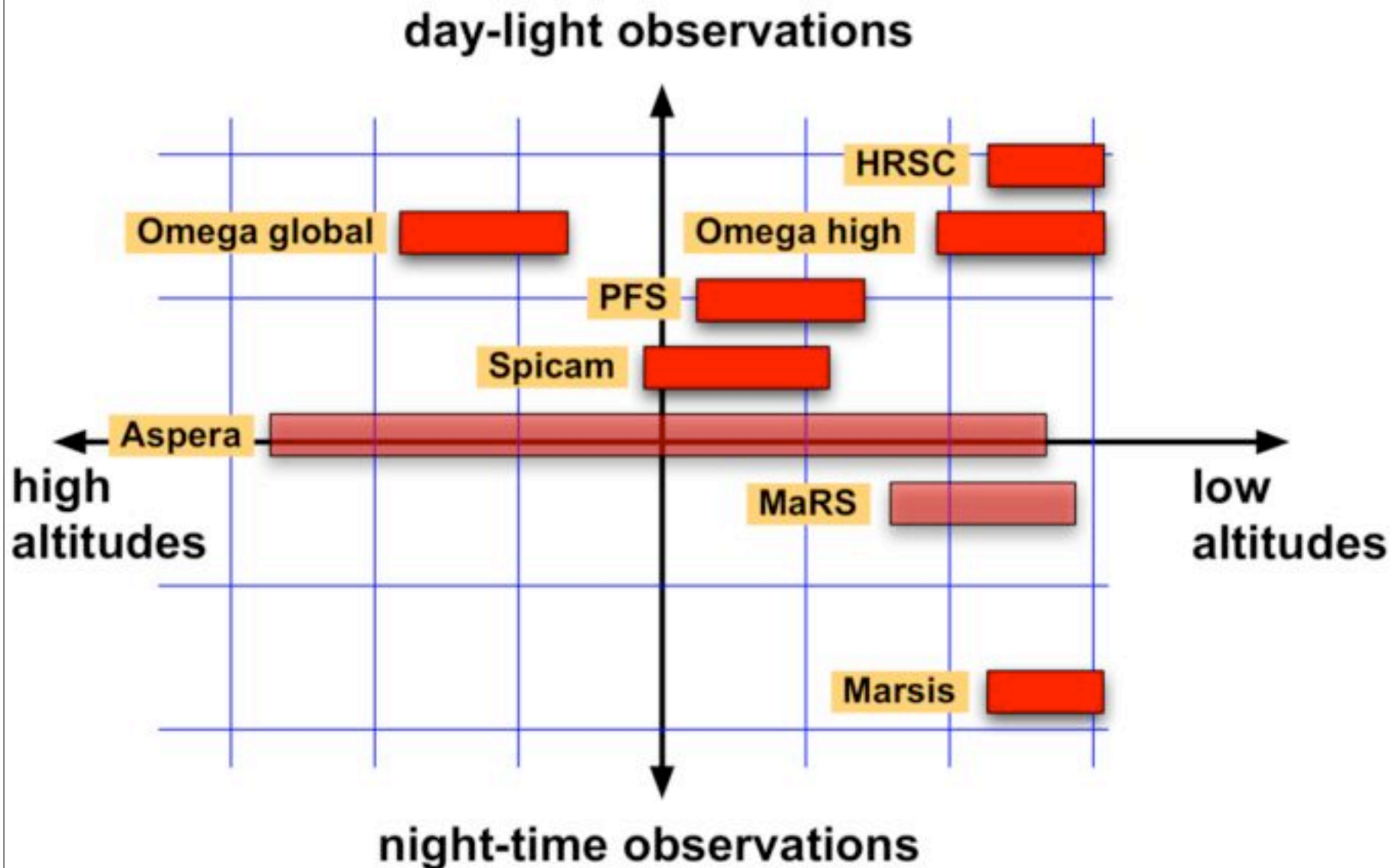
- NNO 35m
- DSN 35m/70m
  - ⬆ flexibility for up/downlink
  - ⬆ data volume



# Instrument operation requests

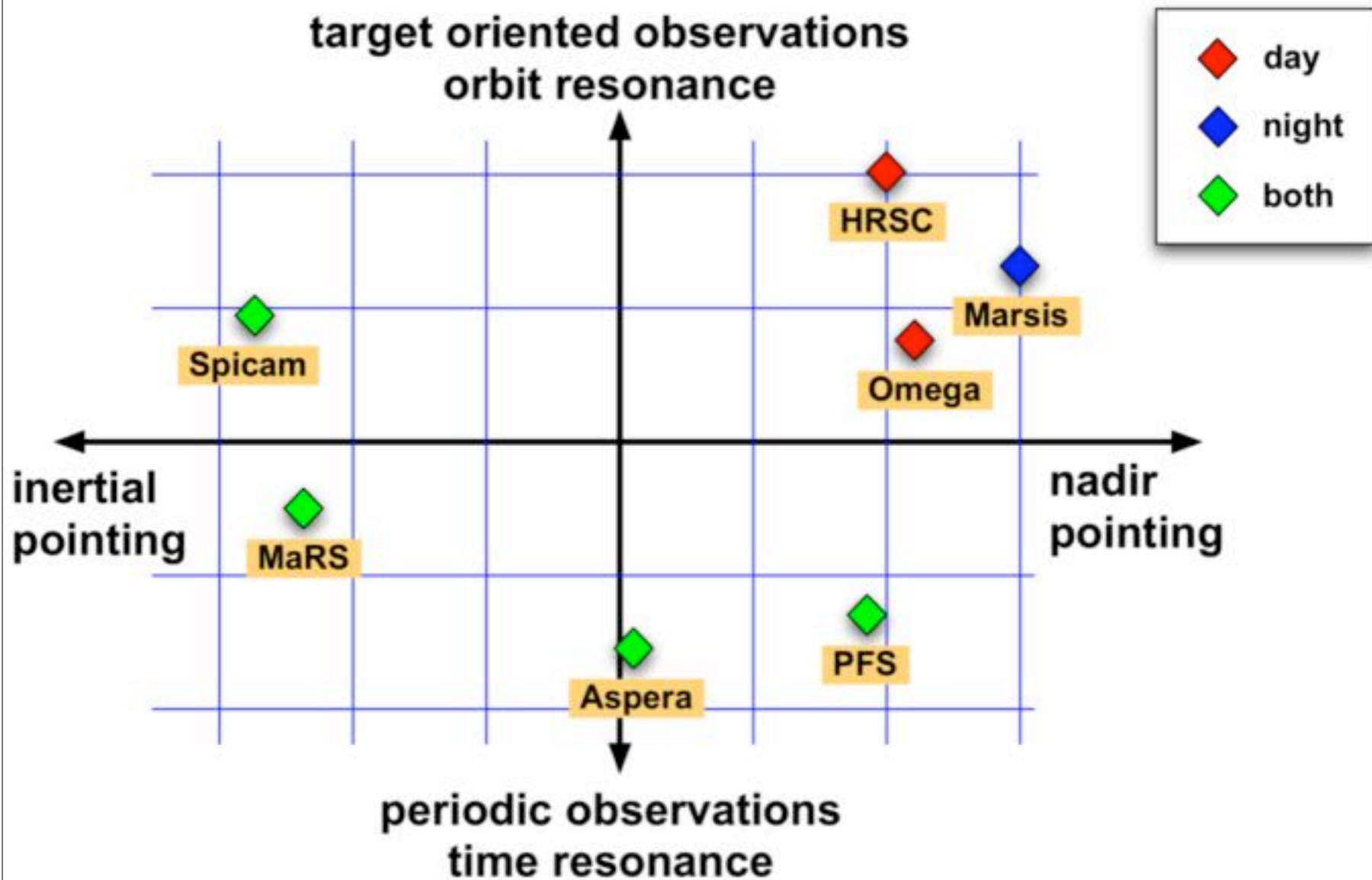
- **Instrument objectives lead to highly diverse operation requests with respect to:**
  - type, position and duration of science pointings
  - periodicity of observations
- **Sharing of resources:**
  - near pericenter prime time
  - number and type of science pointings
  - downlink volume, memory capacity
  - on-board bus data rate

## Instrument requests: illumination and altitude

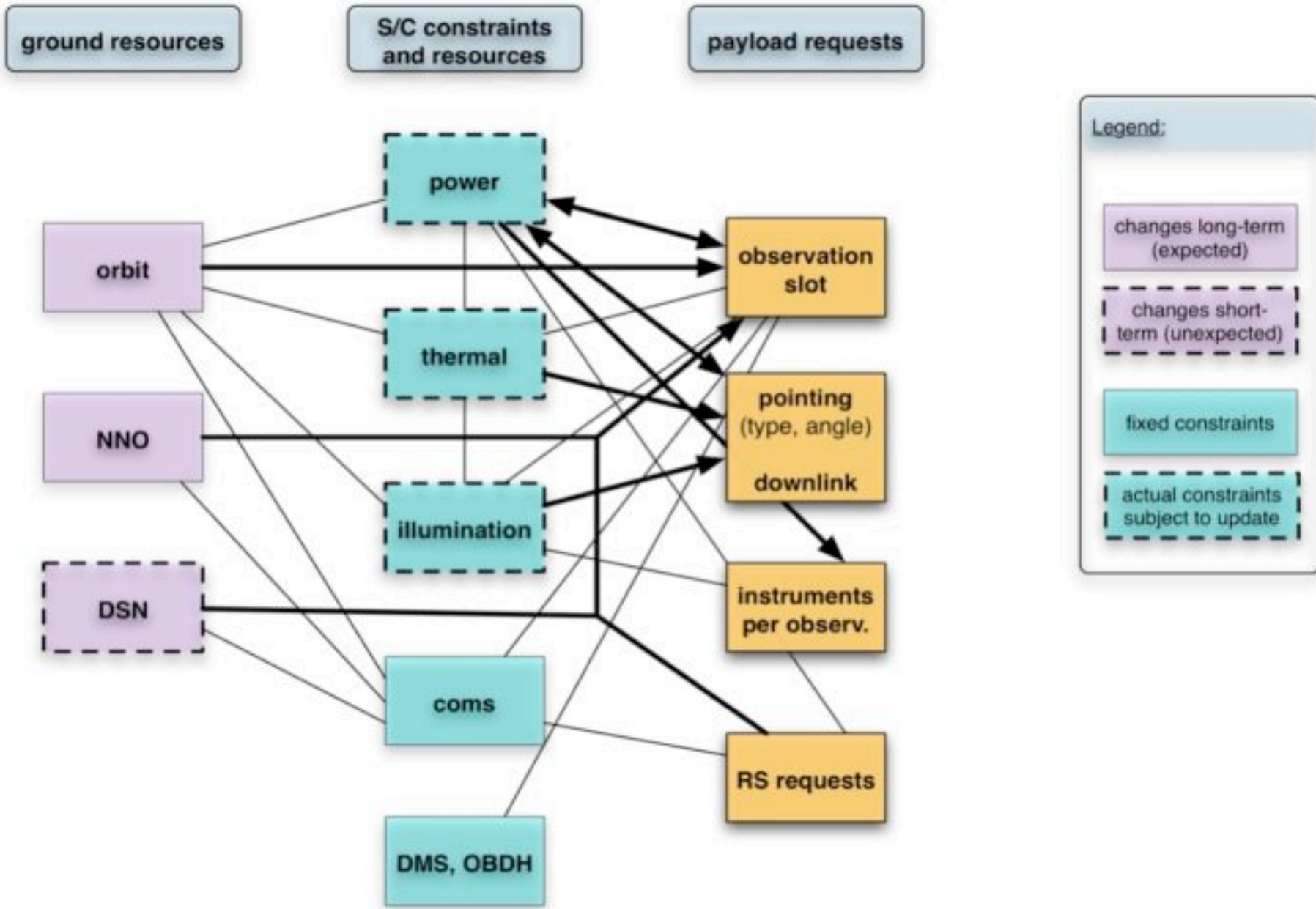




## Instrument requests: pointing and observations periodicity



# Instrument requests and S/C constraints



## Science planning: constraints

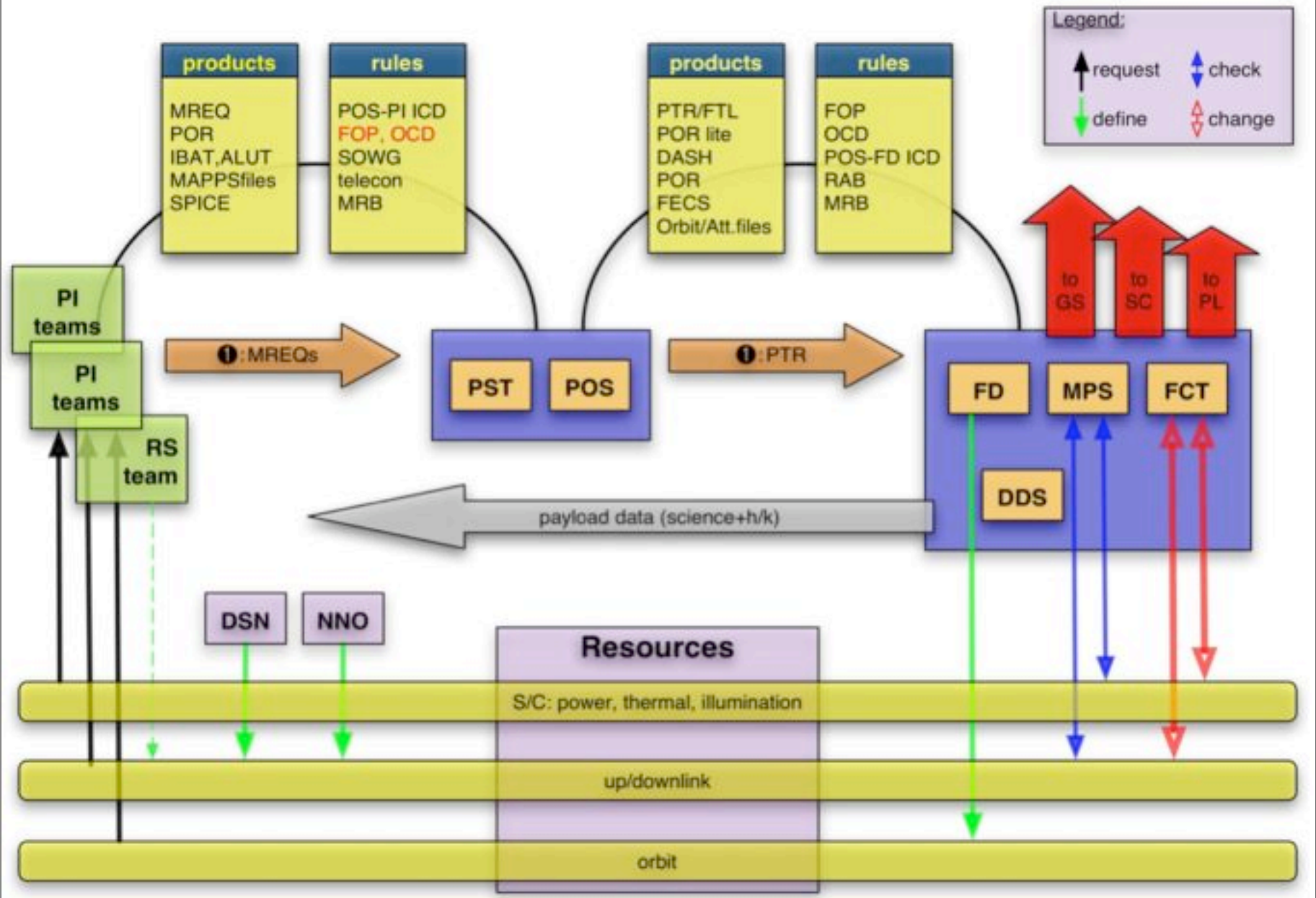
- **objective**
  - fulfill mission science goals
  - optimum use of resources
- **science objectives**                      ➡ **science themes**
- **illum., power etc. constraints**       ➡ **science master plan**      ➡ **priorities per planning period**
- **spacecraft**
  - mid-term planning for 1 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



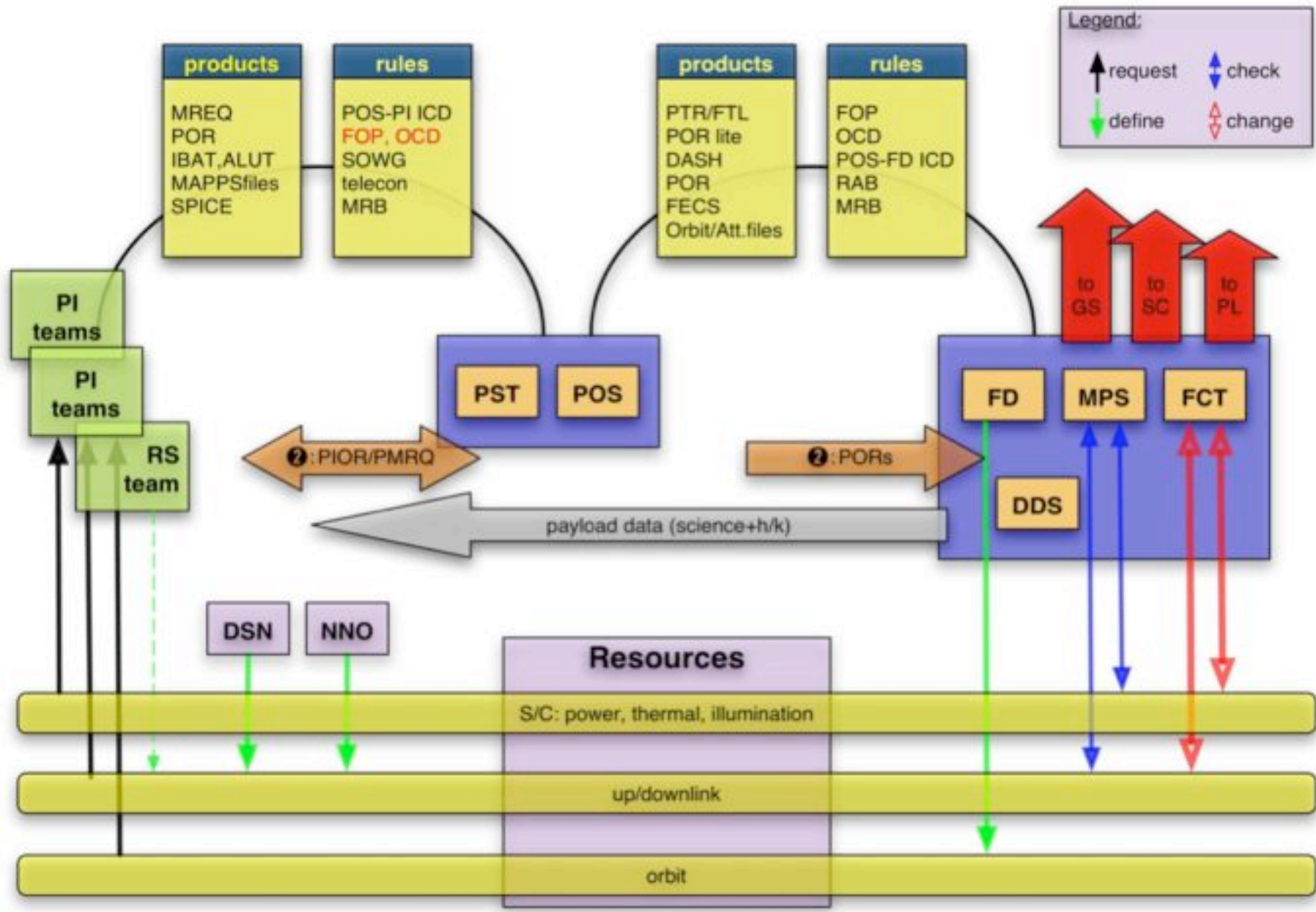
## **Science planning: 2 level process**

- **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 1

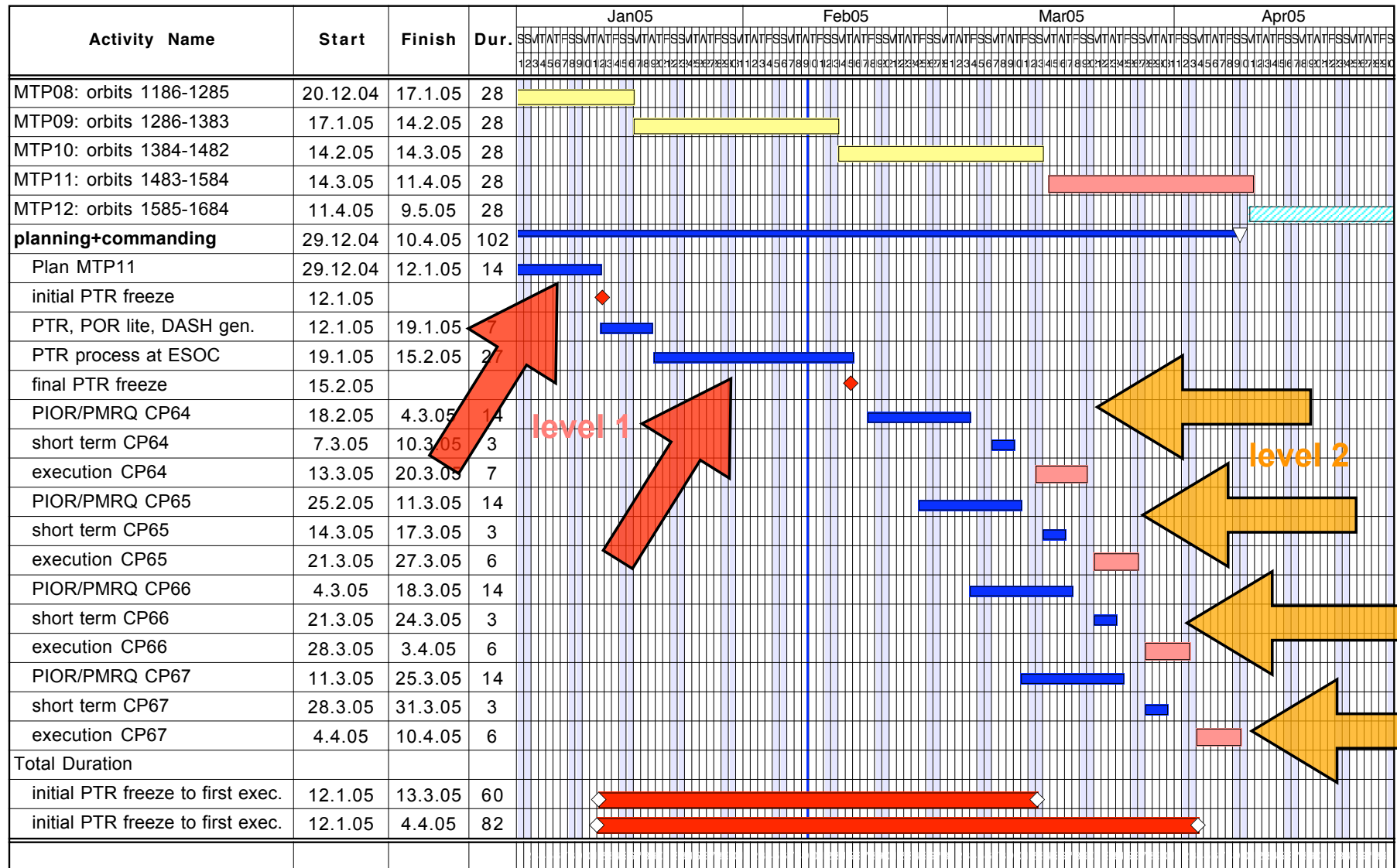


## Science planning: level 2

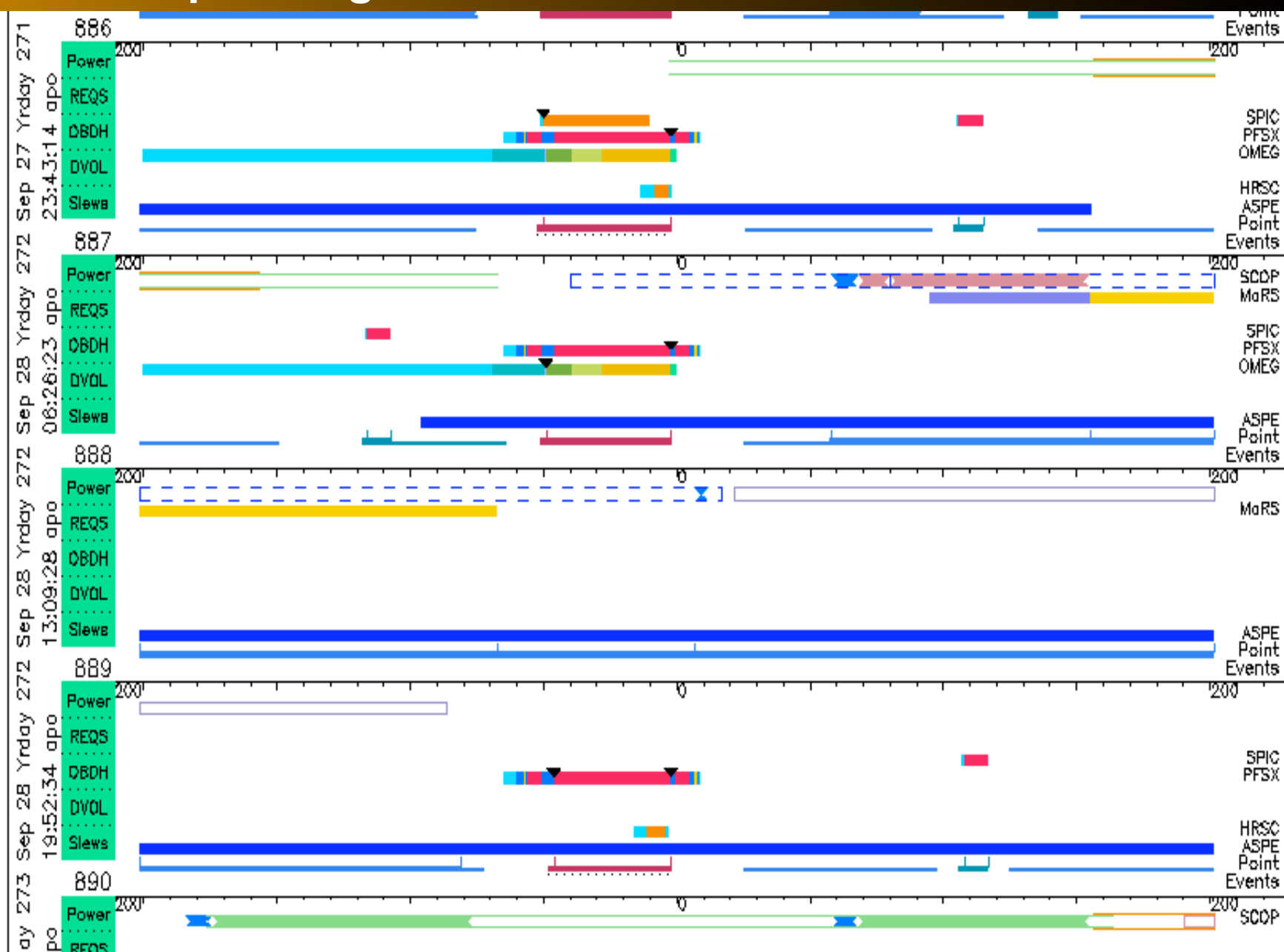




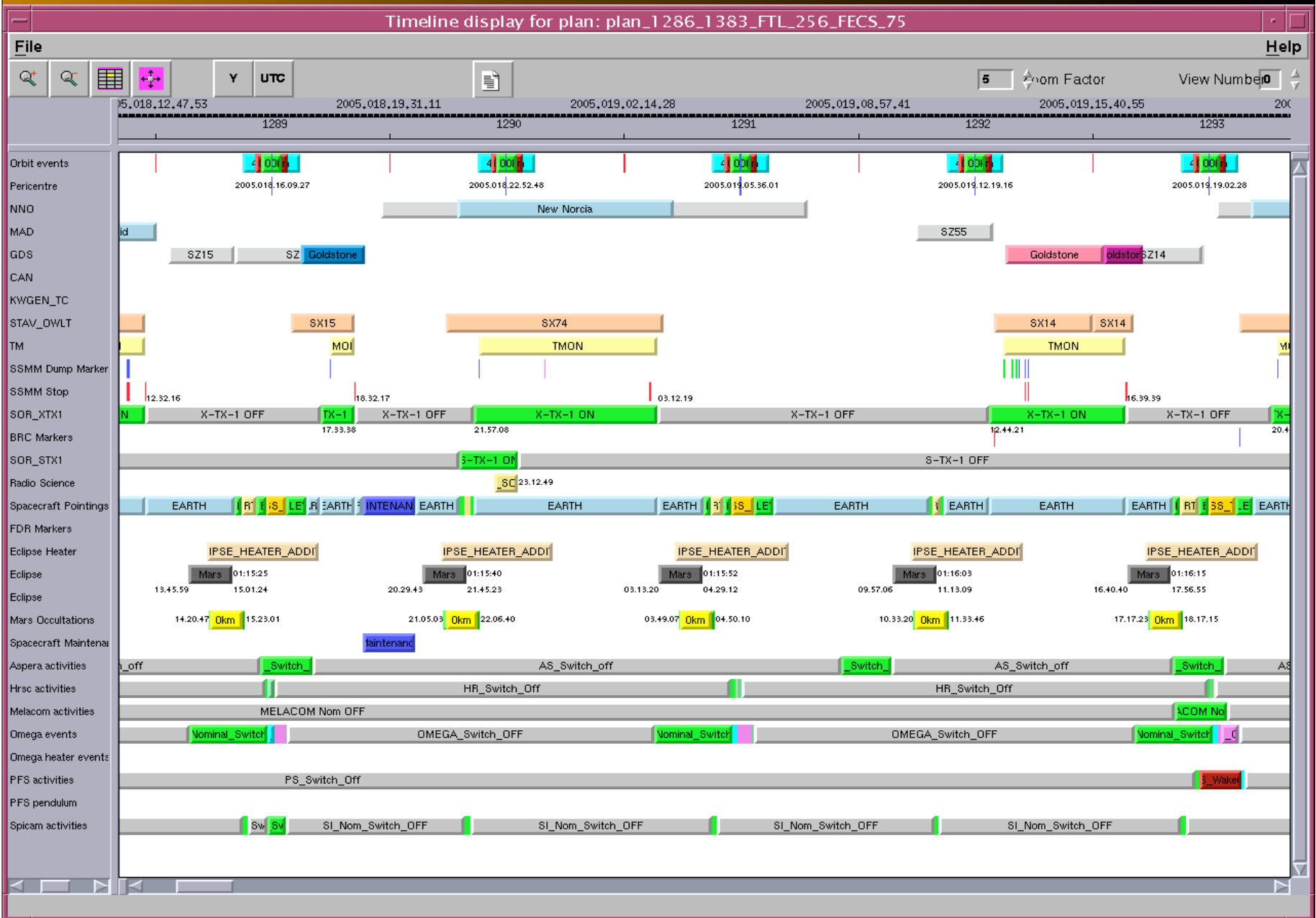
# Science planning schedule



# Science planning: level 1



## Science planning: level 2





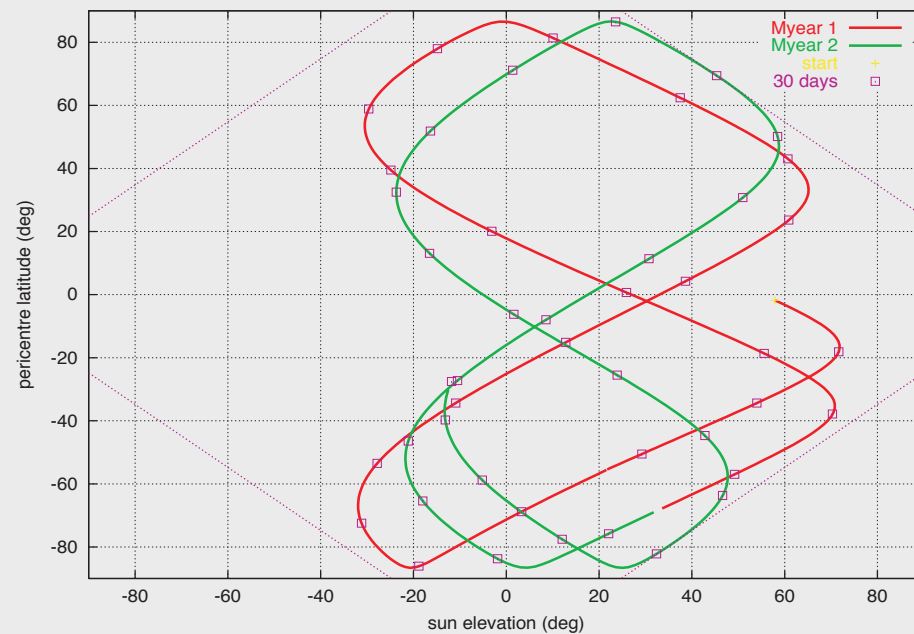
## Science planning achievements

- **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:  $\pm 10$  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

