Jet Propulsion Laboratory
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Operational Complexity in Deep Space Communications

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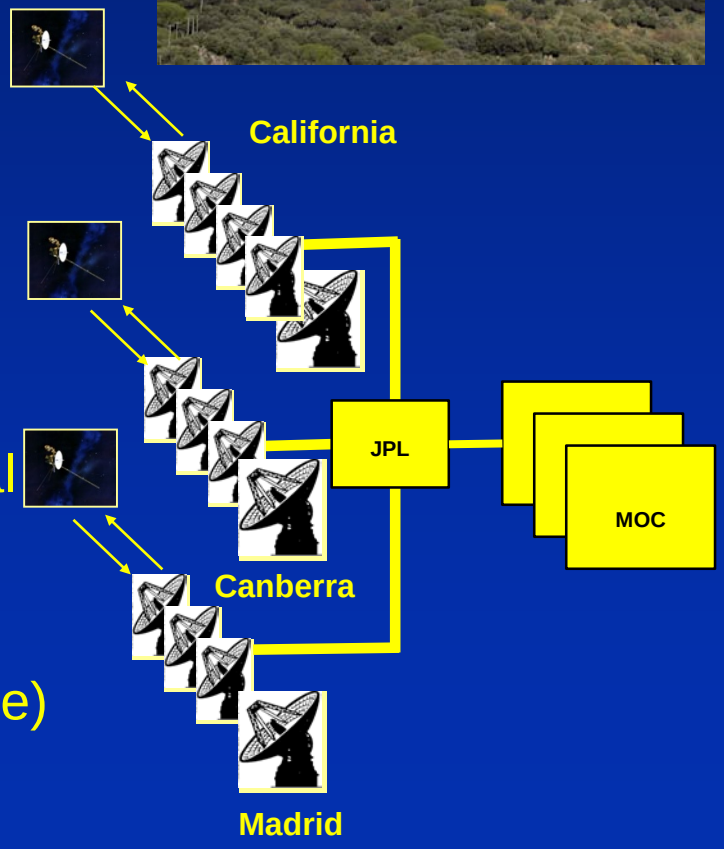
Deep Space Communications

- Deep space - Interplanetary communications
  - Extended to the edge of Solar System
    - Voyager spacecraft ~130 AU
- Difference between deep space and LEO communications
  - LEO: ~1000 km
  - Deep space: ~400,000 km – ~120 AU

Distance	Power reduction
Moon	1.5E+05
Larange points	2.3E+06
Mars	2.3E+10
Jupiter	6.1E+11
Saturn	2.0E+12
Pluto	2.0E+13
Heliosphere	3.3E+14

NASA Deep Space Network

- Provide global coverage at 3 sites around the globe
  - One 70m and three-four 34m antennas at each site
- Support missions from HEO to edge of solar system
- Optimize high performance for deep space communications
  - Compared to typical 10m commercial tracking station
    - Low noise (~4x – 5x advantage)
    - High gain (~10x – 50x advantage)



Drivers of Operational Complexity

- Long distance
- Operational cost constraints

Effects of Long Distance

- Long RTLT
  - Pre-planned operations
    - Mission critical events, e.g., orbit insertion, EDL
    - Automation vs. Interactive changes
- Limited assets
  - Common equipment reconfigured for each mission
    - Large range of supported data rates/power (10 bps – 100 Mbps)
  - Schedule efficiency
    - Packed schedule to meet user's desire/needs
    - Adaptive response to changes, with minimal impact

Effects of Operational Cost Constraints

- Do more with less resources
  - Packed configurations
    - Multiple spacecraft per antenna (when in beam)
    - Multiple links per operator
      - Require good design on human interfaces to minimize errors
  - Increasing reliance on automatic monitor and detection of failures
    - Lessen operator work loads
    - Dependent on equipment's accurate measurements and correct interpretation of events