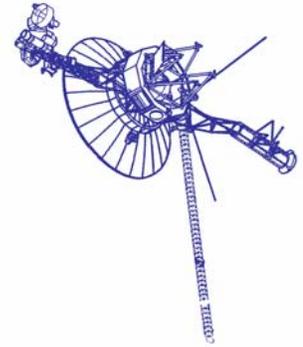




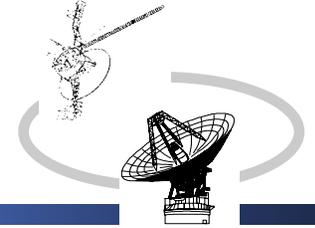
# *NASA Deep Space Network*



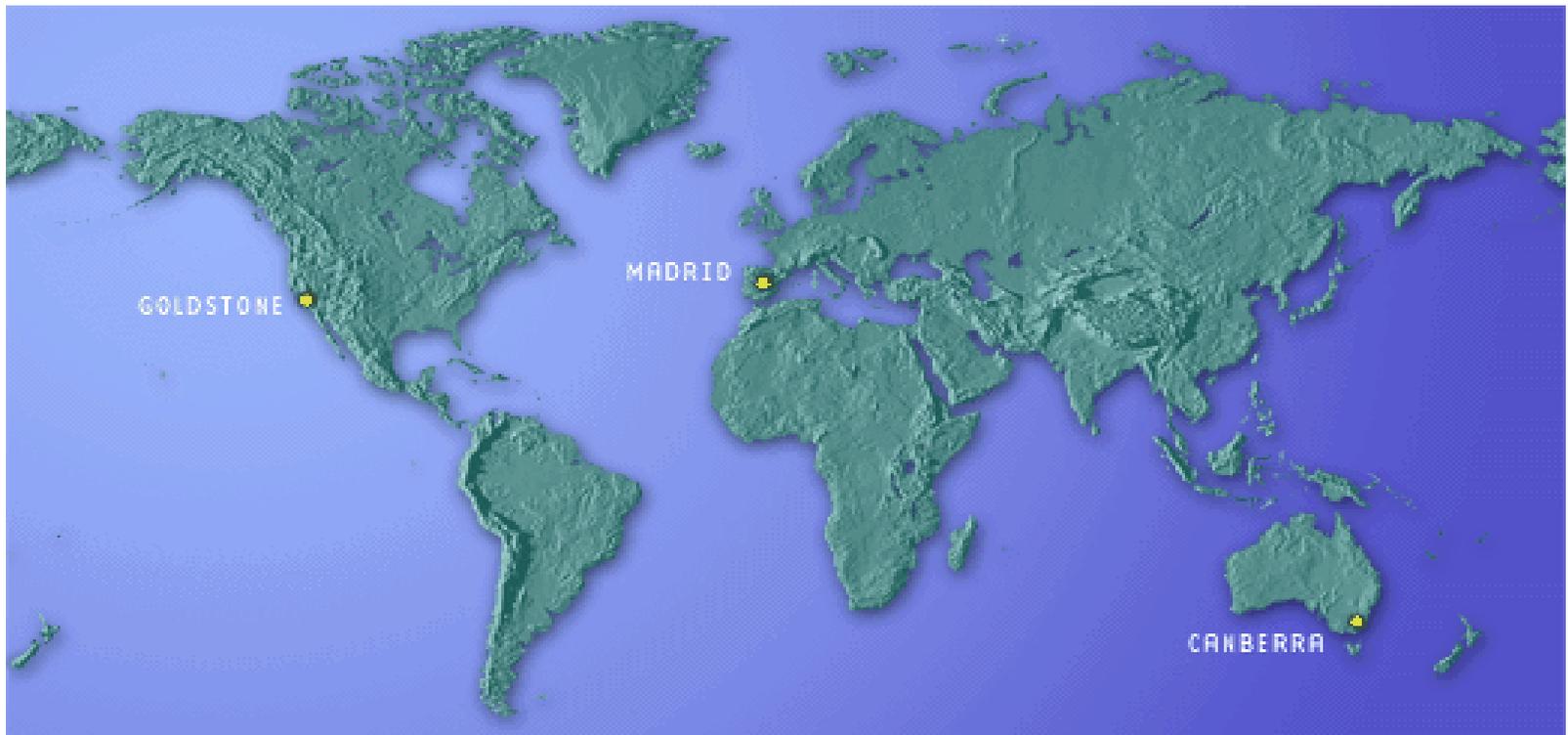


**JPL**

# Deep Space Network



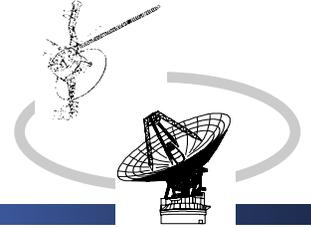
*The Deep Space Network has sites in three locations around the world that hand off to each other allowing continuous contact with a distant spacecraft as Earth rotates.*





**JPL**

# *Deep Space Network*

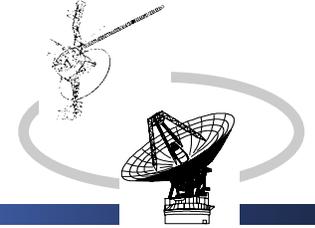


- ☞ **The Deep Space Network is a unique, worldwide network of spacecraft tracking facilities operated for NASA by JPL**
  - **Operated since 1959; JPL was originally part of the Army**
- ☞ **Sites are located at Madrid, Spain; Canberra, Australia and Goldstone**
- ☞ **Locations were originally chosen to assure radio quiet (i.e., surrounded by hills/mountains and away from populated areas) and to provide continuous spacecraft coverage (i.e., approximately 120 degrees apart)**

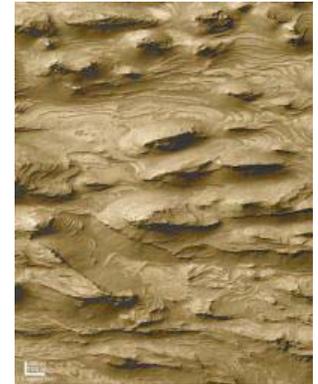
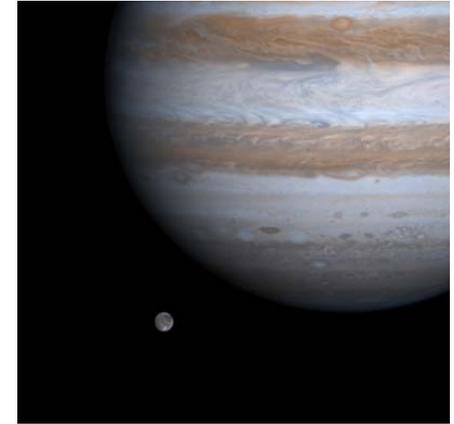


**JPL**

# Deep Space Network



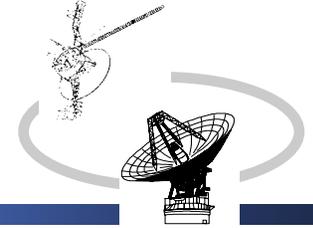
- **Spacecraft Telemetry (downlink)**
  - Collecting the data transmitted by spacecraft
    - Images
    - Data from science instruments
    - Spacecraft health information
- **Spacecraft Commanding (uplink)**
  - Transmitting sequences of instructions from mission controllers to the spacecraft
    - science observations
    - trajectory maneuvers
    - orbit insertions
    - descents and landings
- **Spacecraft Tracking**
  - Calculating predictions as to the position and velocity of a spacecraft based on doppler, range, and interferometry measurements.
- **Navigation**
  - Determining where the spacecraft needs to be and planning necessary trajectory correction maneuvers or orbit trim maneuvers.





**JPL**

# *Deep Space Network*

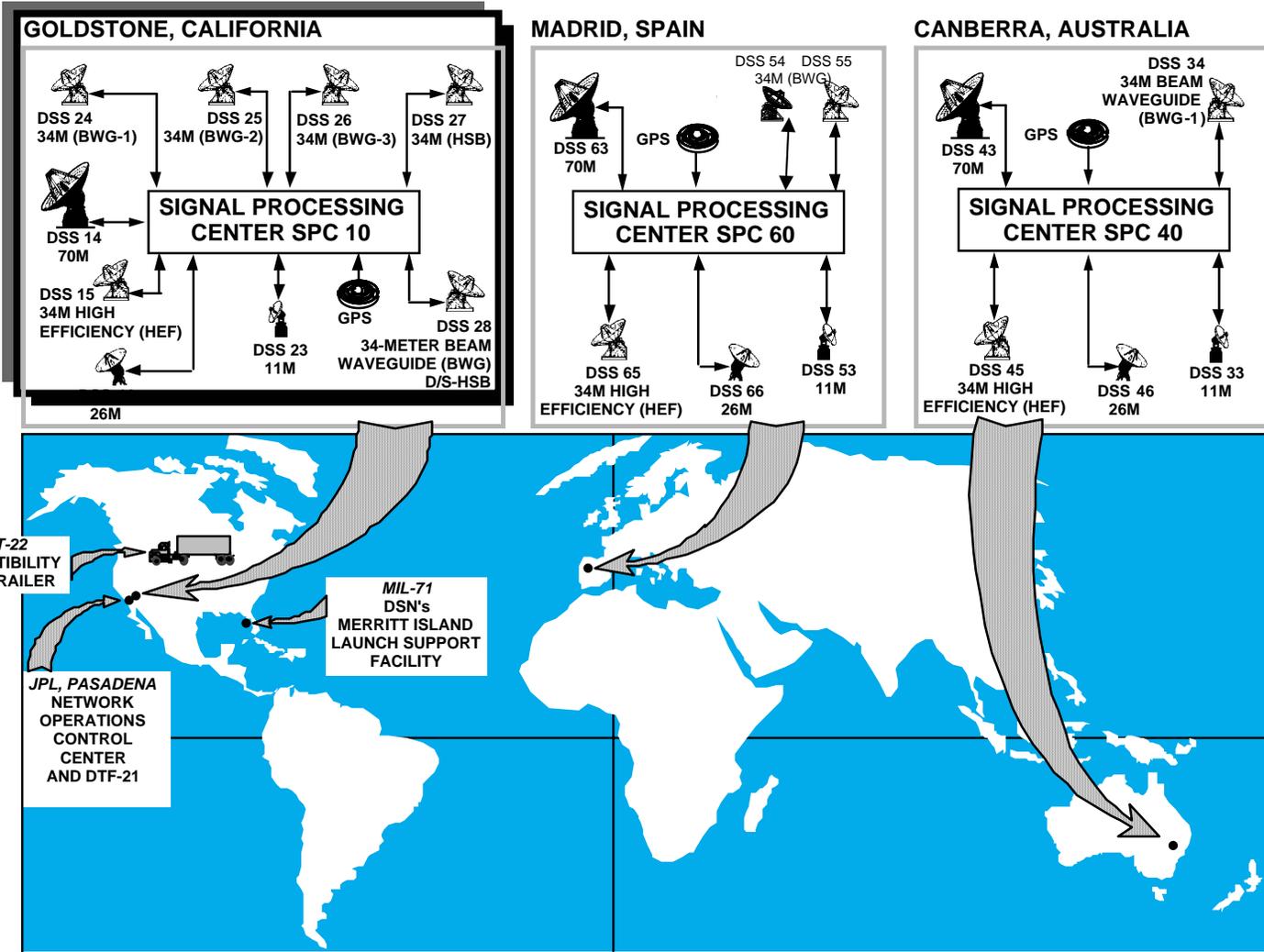
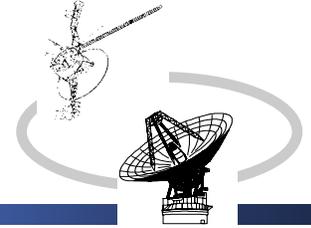


- ☞ **The DSN is solely responsible for navigation, command and data acquisition for NASA high earth orbiters and deep space missions**
  - **Also tracks low earth spacecraft in emergencies and (sometimes) DoD spacecraft**
    - ☞ **Approximately 15 emergency events per year which use high power transmitters and have a two hour call-up window**
  - **Mission set includes approximately 50-60 spacecraft tracked on a regular & emergency basis and includes spacecraft more than 12 billion kilometers from earth -- round trip signal time is more than 23 hours!**
  - **Number of spacecraft is largest in NASA history and increasing**
  - **Similarly, number and length of critical data acquisitions is increasing**
- ☞ **The DSN additionally tracks non-NASA spacecraft launched by other spacefaring nations such as Japan, Germany, France and Russia**



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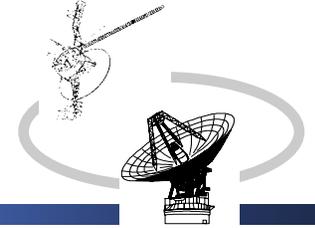
# DSN Facilities





**JPL**

# *DSN Facilities*



## *The three Deep Space Network Sites*



**GOLDSTONE, CALIFORNIA**

QuickTime™ and a  
Photo - JPEG decompressor  
are needed to see this picture.



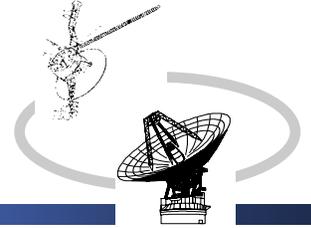
**CANBERRA, AUSTRALIA**

**MADRID, SPAIN**



**JPL**

# *Goldstone DSCC*

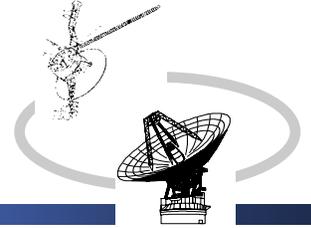


- ☞ **Goldstone Deep Space Communications Complex is the keystone of the DSN**
  - **Largest site with the most antennas: 70m, five operational 34m's, 26m, R&D 34m and 11m and a 34m radio telescope used for educational outreach (including DoD dependent education)**
  - **One 34m includes a radio science system that provides the most stable system ever built and is used for gravity wave detection experiments**
    - ☞ **Stability is the equivalent of one second in 30 million years!**
- ☞ **GDSCC serves also as a center of DSN research and development due to its proximity to JPL**
  - **Installation of new technology and prototype developments to verify system performance**
  - **First article installations**
- ☞ **GDSCC is considered a National Resource by act of Congress**



**JPL**

## *Goldstone DSCC*

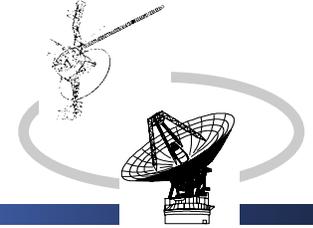


- **Additionally, Goldstone performs continuous wave radar observations of near Earth asteroids, other natural objects and planets**
  - **Uses high power radiation of up to 500KW with extremely weak return signals**
  - **Asteroid tracking is particularly important because of short times from discovery to tracking, extreme public interest and the need to understand the threat they pose to Earth**



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# *Tracking Environment*

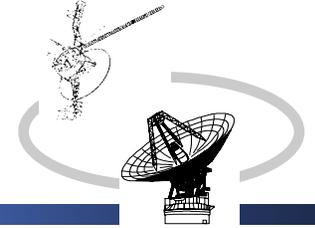


- ☞ **DSN operates at 1.6-1.7 GHz (L), 2.0-2.3 GHz (S), 7.1-8.5 GHz (X) and 31-35 GHz (Ka)**
  - **Eventually will have optical communications capability and 37-41 GHz communications for human exploration of Mars**
- ☞ **DSN sites currently have transmitter powers of up to 400KW at S-Band; 20KW at X-Band; and 50 watts at Ka-Band**
  - **Radar radiates at 500KW at 8.6 GHz**
- ☞ **Deep space spacecraft typically have transmitter powers of approximately 15 watts**
- ☞ **Distances and small spacecraft antennas result in extremely weak received signal conditions**



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# Missions



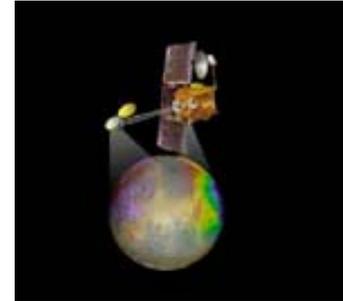
*Spitzer Telescope*



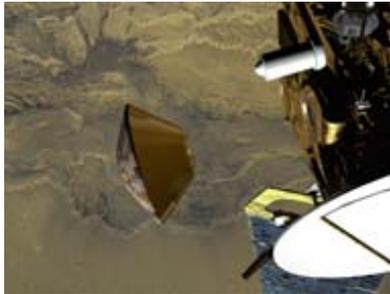
*Cassini*



*Mars Odyssey*



*Mars Express*



*Some missions currently  
being tracked by the DSN*

*Ulysses*

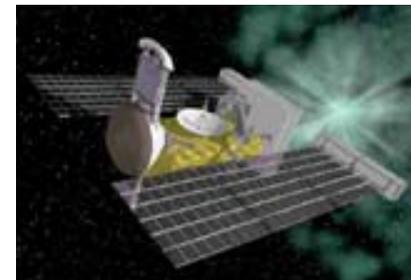


*Mars Exploration Rovers*

*Mars Global Surveyor*



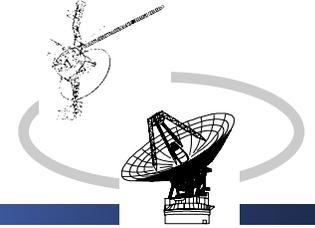
*Stardust*



QuickTime™ and a  
Photo - JPEG decompressor  
are needed to see this picture.



# Characteristics of The DSN



## Received Signal Sensitivity:

The received energy from Voyager at Neptune, if integrated for 300 million years, would be just enough to set off a small photographic flashbulb!

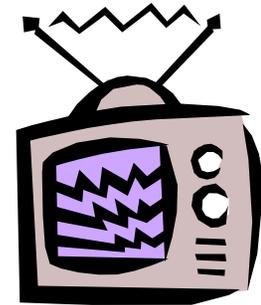
*Received power =  $10^{-17}$  Joules/sec*



## Command Power:

The DSN puts out enough power in commanding Galileo that it could easily provide high quality commercial TV at Jupiter!

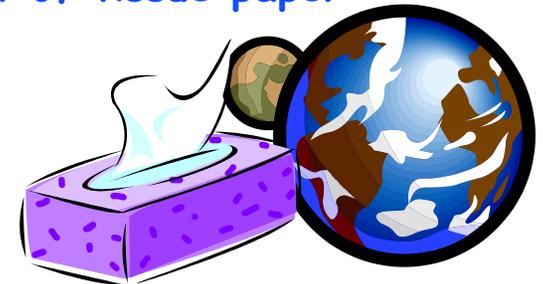
*Transmitted power = 400 kW*



## Dynamic Range of the DSN:

The ratio of the received signal power to the DSN transmitting power is like comparing the thickness of a sheet of tissue paper to the entire Earth!

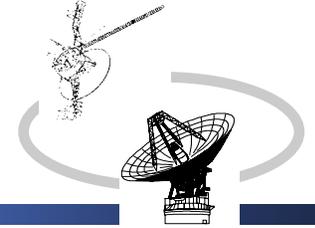
*Ratio =  $10^{27}$*





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## Characteristics of The DSN (2)



### Navigational Accuracy:

Voyager navigation at Neptune was equivalent to being able to tee - off from California and place the ball on a green in Washington, D.C.!

Angular accuracy = 50 nrad



### Frequency Stability:

The DSN's ionic clocks used to achieve this navigation accuracy are so stable that only one second of error would accumulate every 30 million years!

Allan variance =  $10^{-15}$  in 1000 seconds



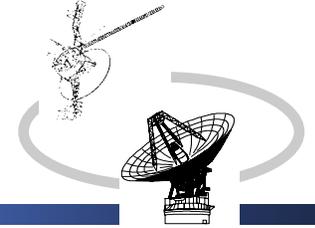
### Once-in-a-lifetime Science Opportunities:

The reliability of a spacecraft and the DSN together is equivalent to driving an automobile for 3 billion miles without a single failure!





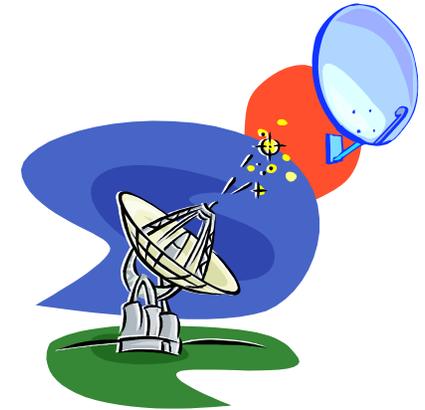
# Characteristics of The DSN (3)



## Signal Levels

The signal level of a 70m antenna receiving a signal from Pioneer 10 is more than a billion times weaker than the signal received by a direct TV system.

**-95 dbm vs. -255 dbm**

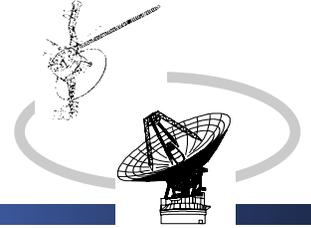


The most distant spacecraft the DSN currently tracks is Voyager 1. The round-trip light time (RTLTL) is 23:12:32. The range to the spacecraft is 12,525 million kilometers.



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# Deep Space Operations Control Center



- The destination point for data received by the antennas at any of the three complexes is the Deep Space Operations Control Center at JPL.
- Data is processed for distribution to Scientists around the world, and archived for future use.
- Commands to spacecraft are transmitted through the operation center.

