NASA's Deep Space Network (DSN)

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Concept for Integrating the DSN with the Caltech ShakeAlert Pilot Project

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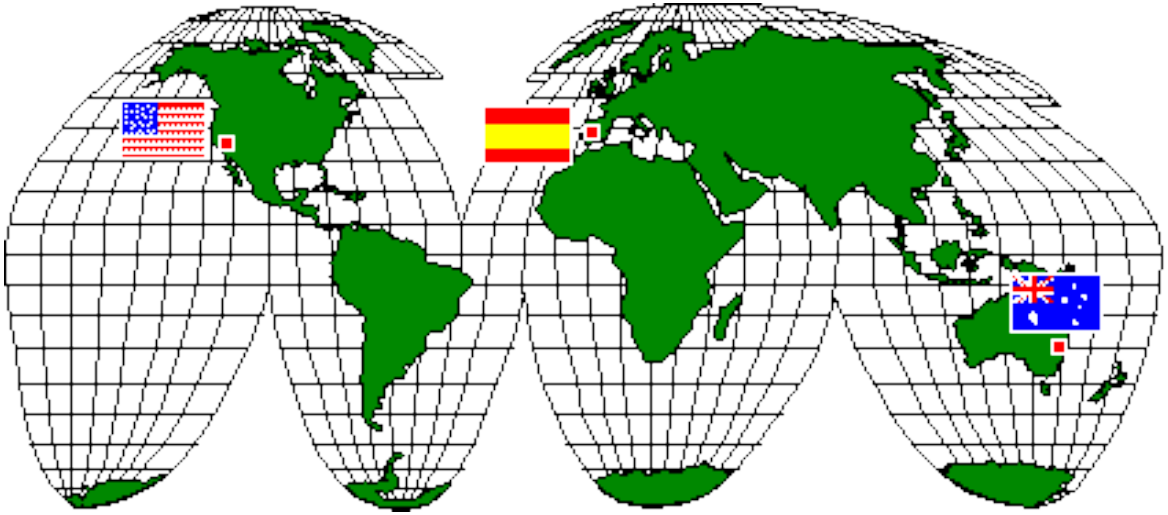
The Deep Space Network (DSN)

- The Deep Space Network - or DSN - is NASA's international array of giant radio antennas that supports interplanetary spacecraft missions
- Tracking all spacecraft from the moon and beyond
- Communicating with messaging as far as 35 Billion miles away and counting
- Solely responsible for navigation, command and data acquisition for NASA high-earth orbiters and deep space missions
- Also track low earth orbit (LEO) spacecraft, support
  spacecraft emergencies, and some Department of Defense (DoD) tracking
- Heart of network located in Pasadena / Monrovia, CA

The Deep Space Network (DSN)

- Every United States deep space mission is designed to allow continuous radio communication with the spacecraft
- Locations in California, Spain, and Australia are approximately 120 degrees apart in longitude, allowing continuous observation
- Continuous 24-hour coverage for several spacecraft requires several Earth-based stations at locations that compensate for the Earth's daily rotation



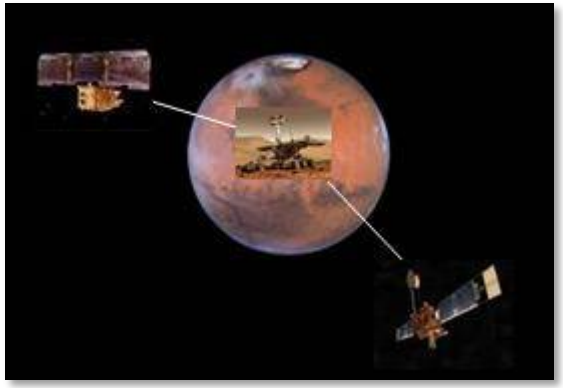
Goldstone Deep Space Communication Complex (GDSCC), Ft. Irwin, CA

Madrid Deep Space Communication Complex (MDSCC), Madrid, Spain

Canberra Deep Space Communication Complex (CDSCC), Canberra, Australia

DSN Communications with Spacecraft

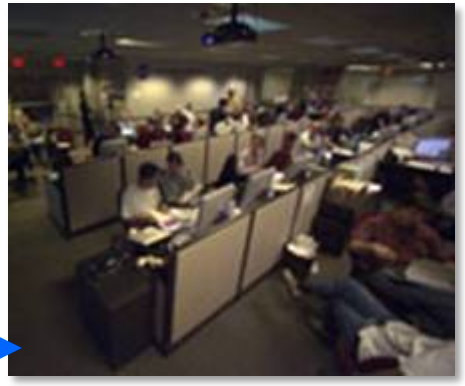
DSN antenna
(70-meter)



Spacecraft
(MRO, ODY, MEX, MER, MSL, etc.)

DSN Complex's Signal Processing Center
(Goldstone, Canberra or Madrid)

Deep Space Operations Center
(JPL)



Mission Support Area
(JPL, NASA, ESA)

Current Status

- The DSN has implemented two Kinemetrics Obsidian 4X Accelerographs at the Goldstone Deep Space Communications Complex (GDSCC). Both of these units are fully operational
  - The units have been installed by Kinemetrics and they have provided training to operate and maintain these recorders
- One of the units is located very close to the 70m antenna DSS-14. The coordinates of the unit are 35.425194 N, -116.889570 E
- One of the units is located adjacent to the three 34m Beam Waveguide Antennas DSS-24, DSS-25, DSS-26. The coordinates of the unit are 35.341485 N, -116.874628 E
  - The data from these two units currently goes into a local network data storage device
- There is a third accelerograph installed at the GDSCC Echo site, 35.30177 N,-116.80574 E. This unit was installed and is maintained by Caltech and is already part of the ShakeAlert network

Current seismic instrumentation configuration at both the Mars and Apollo Sites

Current Plans

- The DSN's intent is to turn operational responsibility for the two DSN installed Accelerographs units over to Caltech, to have them become part of the ShakeAlert network
  - The DSN understands that when this happens, Caltech will change the passwords and logins and will have responsibility for maintaining the units
  - The DSN would like the ability to obtain detailed information on significant seismic events recorded by any of the three units located at GDSCC, to help with our analysis of accelerations that the antennas are subjected to
    - A site for obtaining this data has been provided to a DSN structural engineer

- The DSN plans on developing and deploying a computer that will monitor the ShakeAlert system using GDSCC coordinates and automatically respond to seismic events that are predicted to be above a certain TBD threshold

What the DSN Plans on Doing with the Data

- The DSN is in transition from having operators at each of the three DSN complexes around the world 24 x 7 to having operators at the complex in daylight that have operational responsibility for the antennas at all three complexes
  - The DSN calls this Follow the Sun Operations
    - What it means is that 2/3 of the time GDSCC is running in lights out mode, with only Security staff on site
- The DSN intends to implement auto shutdown and brake setting on the antennas that are tracking before a seismic event strikes, to minimize damage to the antennas
  - Ground acceleration levels for this shutdown need to be further discussed and agreed to by DSN Engineering, Operations and Management
  - The DSN would like to better understand and discuss the prediction accuracy rates (i.e. false positives and confidence intervals of the probability settings, etc.)

What the DSN Plans on Doing with the Data (cont.)

- The DSN computer monitoring the ShakeAlert system is intended to provide DSN notification
  - A notification and basic details of the event and the actions would be logged
  - A notification would be provided to the operations centers at the three DSN sites around the world
  - A notification would be provided to GDSCC Security Staff
  - Text/Email messages would be provided to key DSN Engineering and Management staff via the Earthquake Notification Service

- There are no doors to open, no public paging is planned
  - There is minimal staff at GDSCC, even in daylight

Additional Background on Antenna Shutdowns

- Currently the operators at GDSCC are notified of a seismic event and they make a decision on manual stop on the antennas
- Operators at each of the three complexes also receive warnings when wind speed is above a certain threshold and they manually make a decision to stow the antennas
- Both of these events are under discussion for transitioning to automatic responses, rather than manual commands, as required under Follow the Sun Operations
- A manual override capability for the automatic shutdown will be allowed for times when the DSN is in “critical operations” as opposed to normal spacecraft operations
- The DSN will be evaluating stowing the antennas if adequate advance notice is provided by ShakeAlert.
  - The 70m antenna requires 320 seconds to stow in Elevation, worst case
  - The 34m antennas require 100 seconds to stow in Elevation, worst case
  - It is theoretically possible that the DSN computer monitoring ShakeAlert could communicate to the antenna pointing computer how many seconds of notification there are and the antenna controller could decide to stop and set brakes in the current position, or head towards the stow position and set brakes

Additional Background on Antenna Shutdowns

- The 1992 Landers earthquake did not damage the antennas structurally but did damage the 70m subreflector drive mechanism, causing the subreflector to break free and swing on two of four restraint cables. The design has been improved since this earthquake, but this an example of the type of hazard that we face.

Subreflector Edge Damage

Subreflector Lower Edge Damage