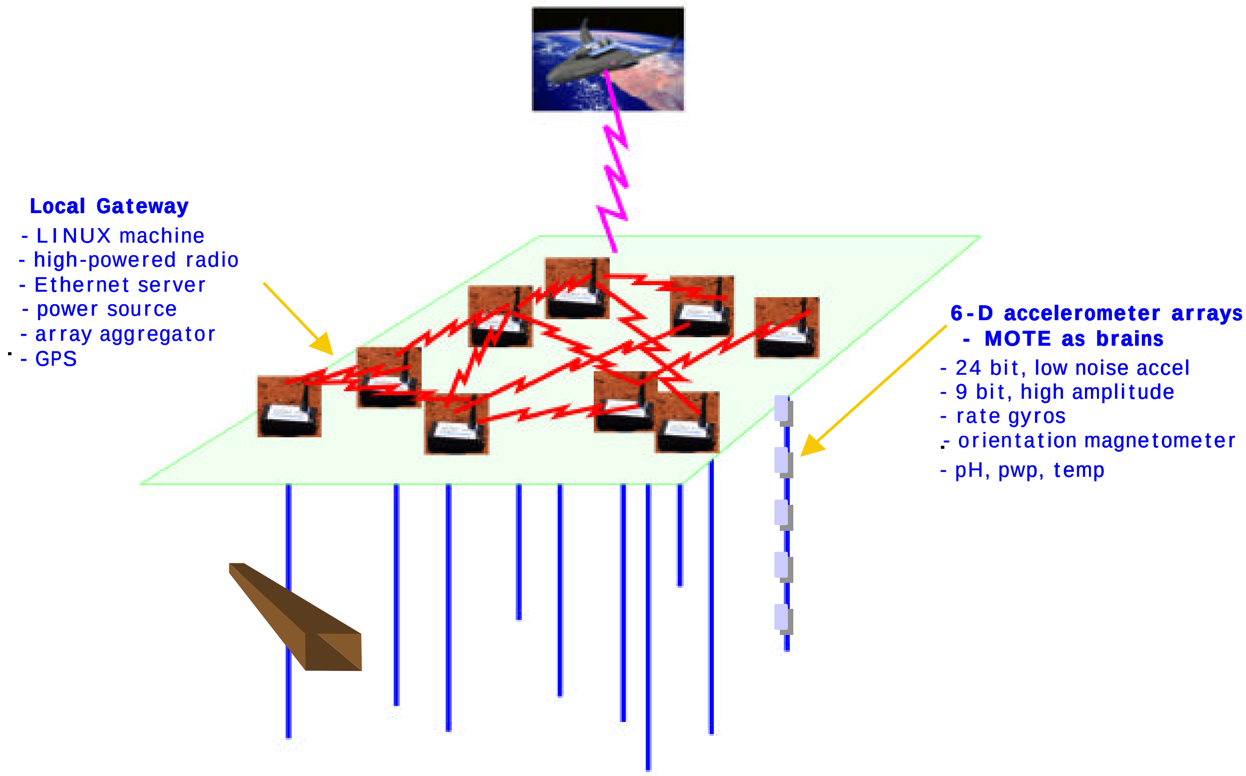
TERRASCOPE - 4-D Distributed Seismic Monitoring Network



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- Each Pod is an independent, MCU-controlled agent with several Mb of non-volatile memory
  - integration of advanced technology accelerometers (30 $ng_{rms}/\sqrt{Hz}$ noise floor, 24-bit direct digital); dynamic range to 1.5g.
  - Tilt (pitch and roll) with 0.003 degree repeatability
  - Azimuth ~ 0.1 degree repeatability
  - Real-time clock within 0.5 ms
  - Parametric measurands include temperature, pH, pore water pressure, etc.
- Local Gateway integrates solar power, improved batteries, GPS timing, and ethernet server
- Fully dynamic networking, real-time reprogramming and peer-to-peer sensor fusion

The Terra-Scope system is an affordable 4-D seismic monitoring system based on independent, microprocessor-controlled Pods. The pods are nominally 50 mm in diameter, and about 120 mm long. They are expected to cost approximately $5000 each. An internal 16-bit, extremely low power MCU controls all aspects of instrumentation, 8 PGAs, and local signal storage. Each pod measures 3-D acceleration, tilt, azimuth, temperature, and other parametric variables such as pore water pressure and pH. The following parameters are independently controllable at each pod: pre-trigger length, post-trigger length, trigger time stamp, sampling rate, trigger level, trigger parameters, non-volatile storage, and calibration and self-evaluation. Each pod communicates over a standard digital bus (e.g. RS-485) through a complete GUI interface.

Three dimensional acceleration is measured by an all digital force-balance servo MEMS accelerometer. This accelerometer has a dynamic range of more than 115 dB and a frequency response from DC to 1000 Hz. This accelerometer chip uses a 5th order delta-sigma feedback loop to yield a noise floor of less than 30 $ng_{rms}/\sqrt{Hz}$. The device has a power consumption of less than 150 mW. Accelerations above 0.2 g are measured by a second set of MEMS-based accelerometers, giving a full 160 dB dynamic range.

At the head of each array sits a local gateway (LG), about a 75 mm cube. The LG is based on a variable clocked RISC-based LINUX machine with large static memory and an embedded ethernet server. The WAN connection is wireless (e.g., direct radio link, two-way satellite) or wired as is convenient. The LG will aggregate and process the multiple data streams from array stations, and either push the data onto the web or store it until queried by the main server. Included in the LG is a GPS which will provide exact timing for all the array stations, as well as providing accurate array location. Local batteries are charged by an attached solar array, and when possible a hard-wired powered ethernet link will provide ample power for the entire array. The system architecture addresses the possibility of disconnection at every level. Each layer (sensor nodes, gateways, base stations) has some persistent storage which protects against data loss in case of power outage. Each layer also provides data management services. While many types of communication can be unreliable, when it comes to data collection, long-latency is preferable to data loss.