The EarthScope Facility:

A new experiment in cooperative solid earth science

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CORS Forum
CGSIC 42nd Meeting
8-9 September 2003
Portland, Oregon

Objectives of Presentation

- Provide an overview of EarthScope
- Provide more detail about PBO
- In the process, I hope you will see that:
  - We need good monuments where ever possible (i.e. in CORS when possible)
  - We need assistance in permitting
  - We need assistance in recruiting

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A New View into Earth

A Science and Facilities Program for study of the structure, dynamics and evolution of the North American continent

EarthScope Components

USArray US Seismic Array

Integrated system of seismic arrays to provide a coherent 3-D image of the lithosphere and deeper Earth

PBO Plate Boundary Observatory

Arrays of strainmeters and GPS receivers to measure real-time deformation on a plate boundary scale

InSAR **In**terferometric **S**ynthetic **A**perture **R**adar

Images of tectonically active regions providing spatially continuous strain measurements over wide geographic areas.

SAFOD San Andreas Fault Observatory at Depth

A borehole observatory across the San Andreas Fault to directly measure the physical conditions under which earthquakes occur

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The E&O component of Earthscope

- Stimulate public interest in science
- Support for basic research
- Develop human resources
- Siting for USArray & PBO instruments

- Inquiry-based learning
- Interaction between disciplines
- Interaction between schools
- New instructional tools

EarthScope Science Goals

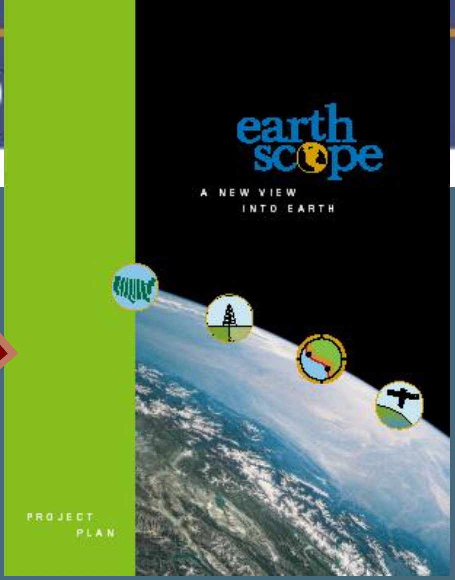
- Structure and evolution of the continent
- Earthquake processes and seismic hazards
- Magmatic processes and volcanic hazards
- Active deformation and tectonics
- Continental geodynamics
- Fluids in the crust
- Exploration and Discovery

Data Policy

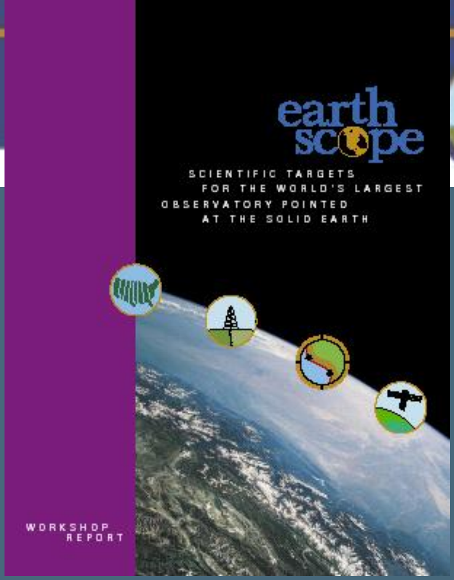
- PBO GPS data, Big Foot seismic data
  - Completely open data policy
  - Immediate unrestricted access to all data
- Portable GPS
  - Open data policy (unless community rebels)
- Flexible Pool seismometers, SAFOD experiments
  - Data subject to a period of exclusive use, if funding agency concurs with Investigator’s request

EarthScope Planning

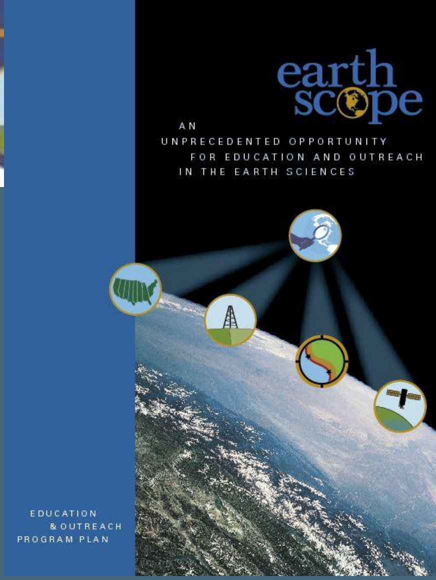
- 1992 - 1996
  - Concept development
    PBO, Array USA, InSAR
    San Andreas Fault Zone Drilling
- 1997 - 1998
  - Discussions with NSF
  - Workshops and Steering Committees
- 1999
  - EarthScope integration
  - ES Working Group established
  - Nat. Science Board Approval
- 2000
  - FY01 NSF Budget
    - Not funded by Congress
- 2001
  - Program Plan
  - NRC EarthScope review
  - NRC BROES report
  - FY02 NSF Budget
    - No new starts
- 2002
  - E&O Workshop
  - Canada/Mexico/US discussions
  - Ocean Mantle Dynamics WS
  - EarthScope in FY03 request



EarthScope Project Plan



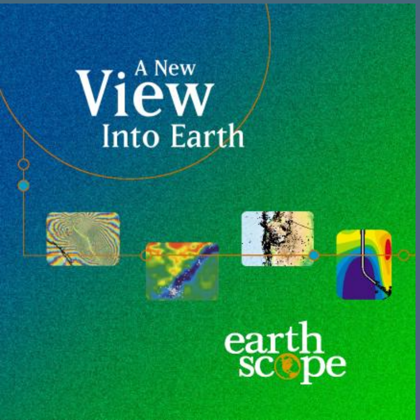
EarthScope Science Workshop

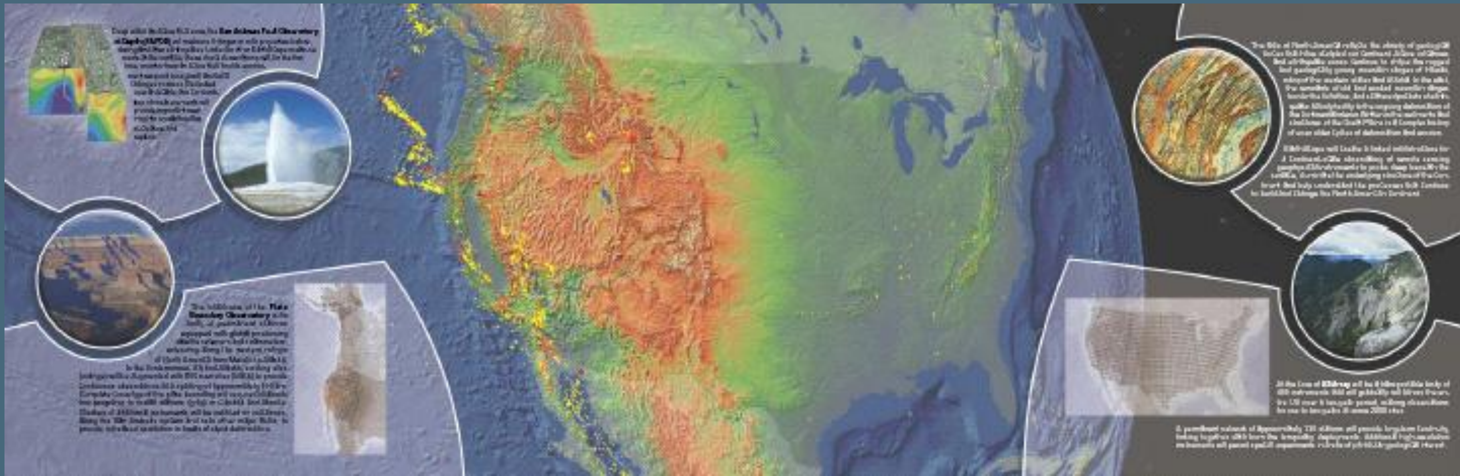


Education and Outreach Program Plan

USArray and PBO Workshops

EarthScope Planning Documents





National Academy of Sciences' Review of EarthScope

Special Panel to review EarthScope Integrated Science, NRC, 2001

The Committee concludes

that the scientific rationale for EarthScope is sound,

that the scientific questions to be addressed are of significant importance, and

that no necessary components have been omitted.

The Committee recommends that all four EarthScope components be implemented as rapidly as possible."

EarthScope - Current Status

- The FY 2003 funding has been approved for the National Science Foundation to initiate construction of EarthScope: USArray, San Andreas Fault Observatory at Depth (SAFOD), and Plate Boundary Observatory (PBO) at $30.0 million.
- An MREFC proposal was submitted by IRIS, Inc., UNAVCO, Inc. and Stanford University to initiate construction of the first 3 components of the EarthScope facility.
- The proposal has received approval at all levels of NSF. We are waiting on final signatures on Cooperative Agreements.
- We anticipate a start date of 1 September 2003, with funding shortly thereafter.
- Funding is still being sought for InSAR.
- The expected operational lifespan of EarthScope is 15 years

EarthScope Facilities Executive Committee

• Greg van der Vink	EarthScope Facility Project Director
• David Simpson	IRIS Consortium President, PI-USArray
• William Prescott	UNAVCO Consortium President, PI-PBO
• Mark Zoback	Stanford, PI-SAFOD
• Goran Ekstrom	Harvard, Chair, IRIS Board
• Steve Hickman	USGS, Co-PI SAFOD
• Paul Silver	Carnegie, UNAVCO Board

Challenges Ahead

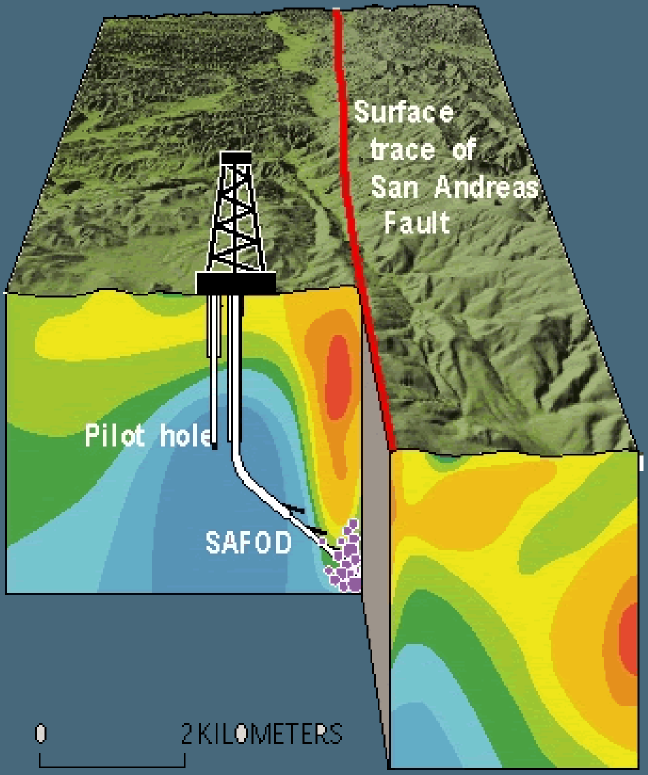
- Install, evolve and maintain the core MREFC facility
- Develop and Integrate:
  - Education & Outreach
  - Information Technology

  and Get InSAR funded!
- Engage the next generation of Earth Scientists

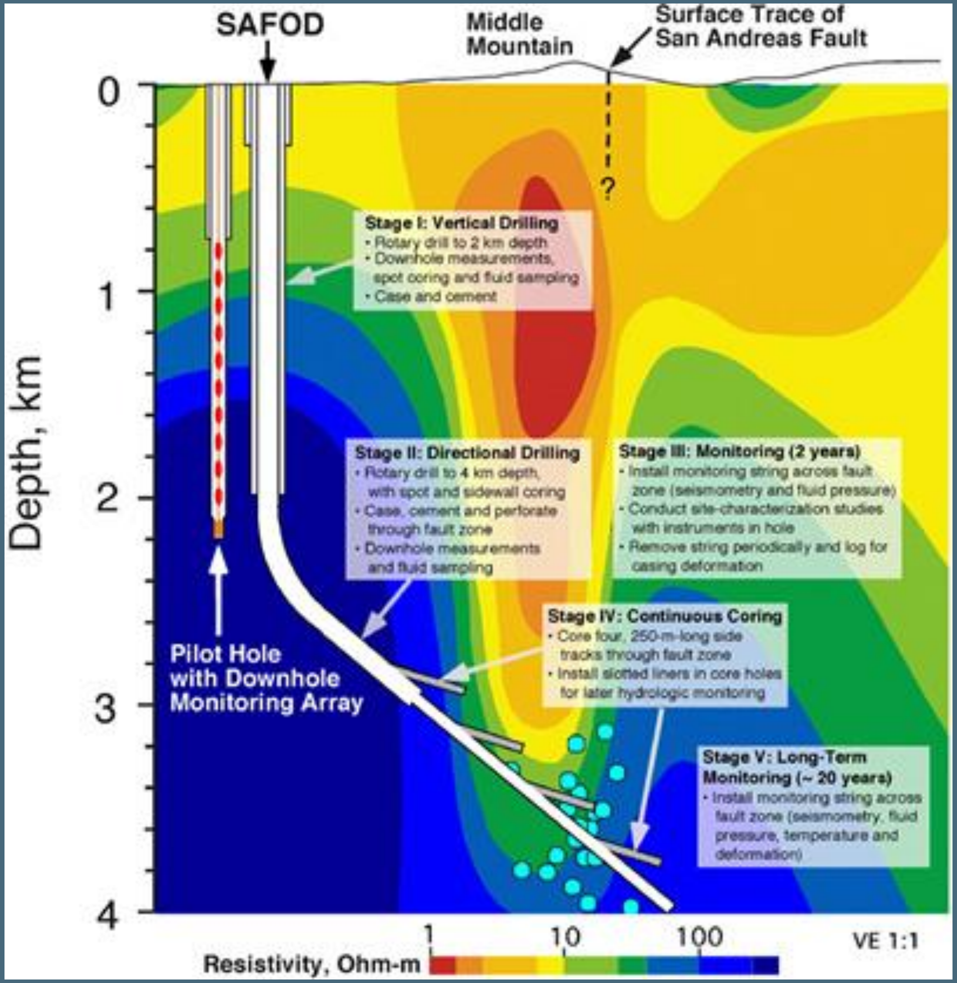
www.EarthScope.org

SAFOD

Drill 4 km into zone of microearthquakes at the nucleation point of the 1966 Parkfield M 6 earthquake



SAFOD



SAFOD

drill into, or very close to,
a repeating microearthquake source.

Recover rock and fluid samples

determine their compositions,
deformation mechanisms,
frictional behavior and
physical properties.

Instrumented observatory

Monitor earthquakes, deformation, and fluid pressure through multiple earthquake cycles

Learn

Composition of fault zone materials

Constitutive laws that govern their behavior;

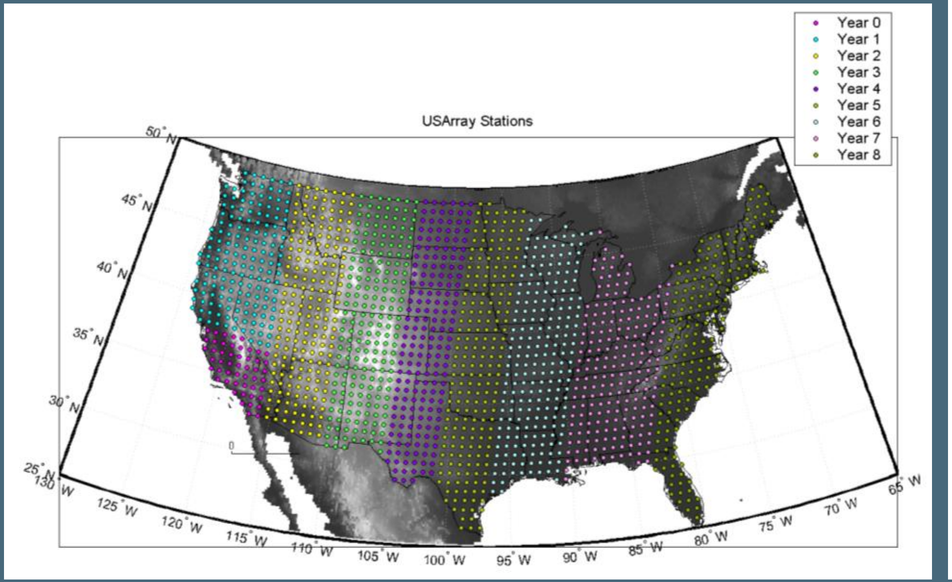
Measure the stresses that initiate earthquakes and control their propagation

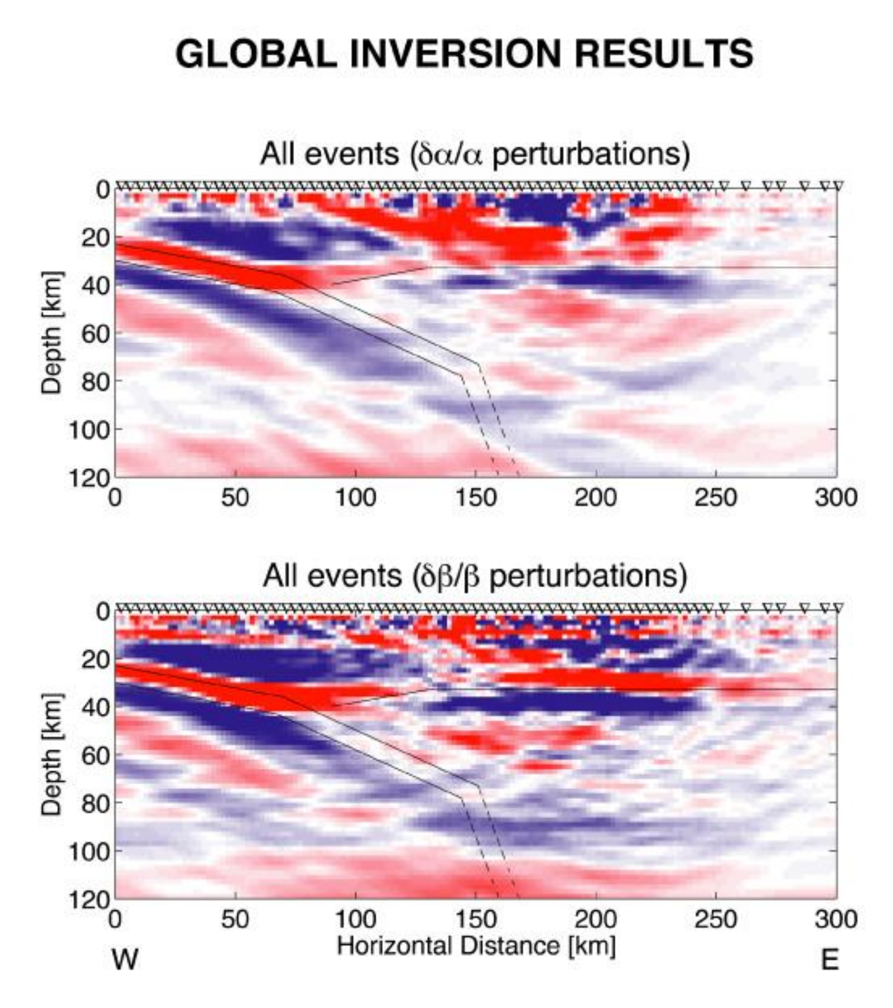
Test hypotheses on the roles of high pore fluid pressure and chemical reactions in controlling fault strength and earthquake recurrence;

Observe the strain and radiated wave fields in the near field of microearthquakes.

USArray

Probe the three-dimensional structure beneath continental North America, using a spatially dense network of high-quality seismic stations.

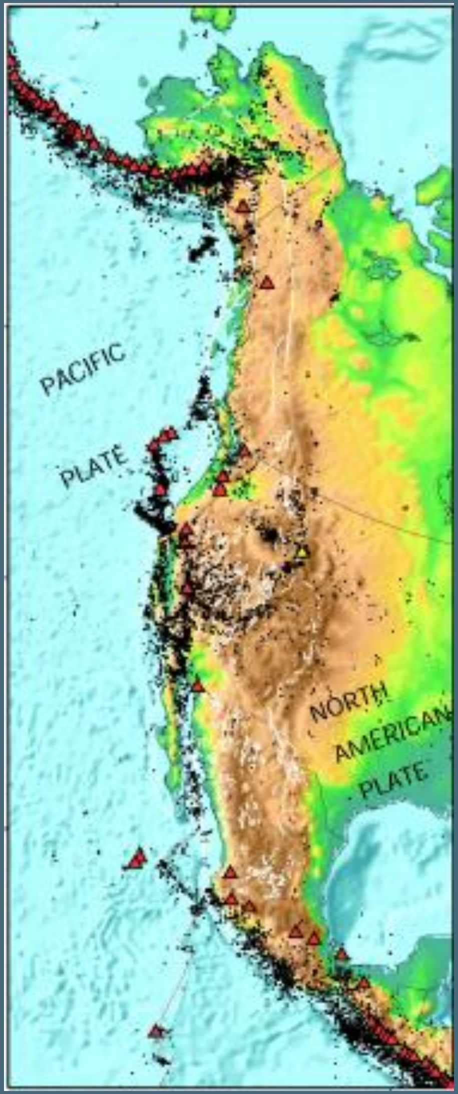




USArray

- Transportable Continental scale Array ("Bigfoot")
    - 400 station broadband array
    - 1500 - 2000 observation sites over 10-12 years
- Flexible Pool
    - 200 - short period
    - 200 - broadband
    - 2000 - single channel active source receivers
- Permanent Reference Network
  - In collaboration with USGS ANSS network
    - 25 GSN + 10 NSN quality USArray stations
    - total ANSS backbone of ~125 stations
    - 16 geodetic quality GPS receivers

Plate Boundary Observatory



Designed to study the three-dimensional strain field resulting from plate-tectonic deformation of the western portion of the continent

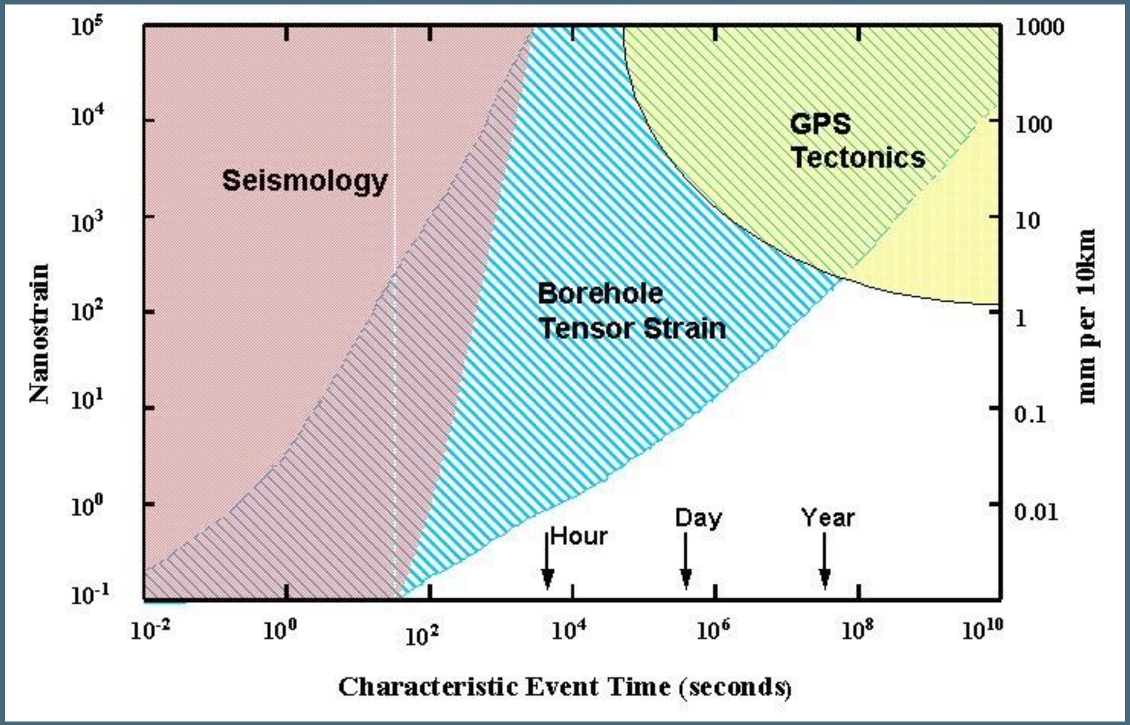


Plate Boundary Observatory

- Focused, dense deployments of GPS and strain
  - 775 continuous Global Positioning Systems
  - 175 borehole strainmeters
  - 5 long baseline strain components
- Backbone network of GPS stations
  - 100 sites to provide a long-wavelength, long-period synoptic view of the entire plate boundary zone
  - Receiver spacing will be approximately 200 km
- Portable GPS receivers
  - Pool of 100 portable GPS receivers for temporary deployments to areas not sufficiently covered by continuous GPS
- Geo-PBO
  - Image acquisition
  - Image archive
  - Enhanced dating laboratories

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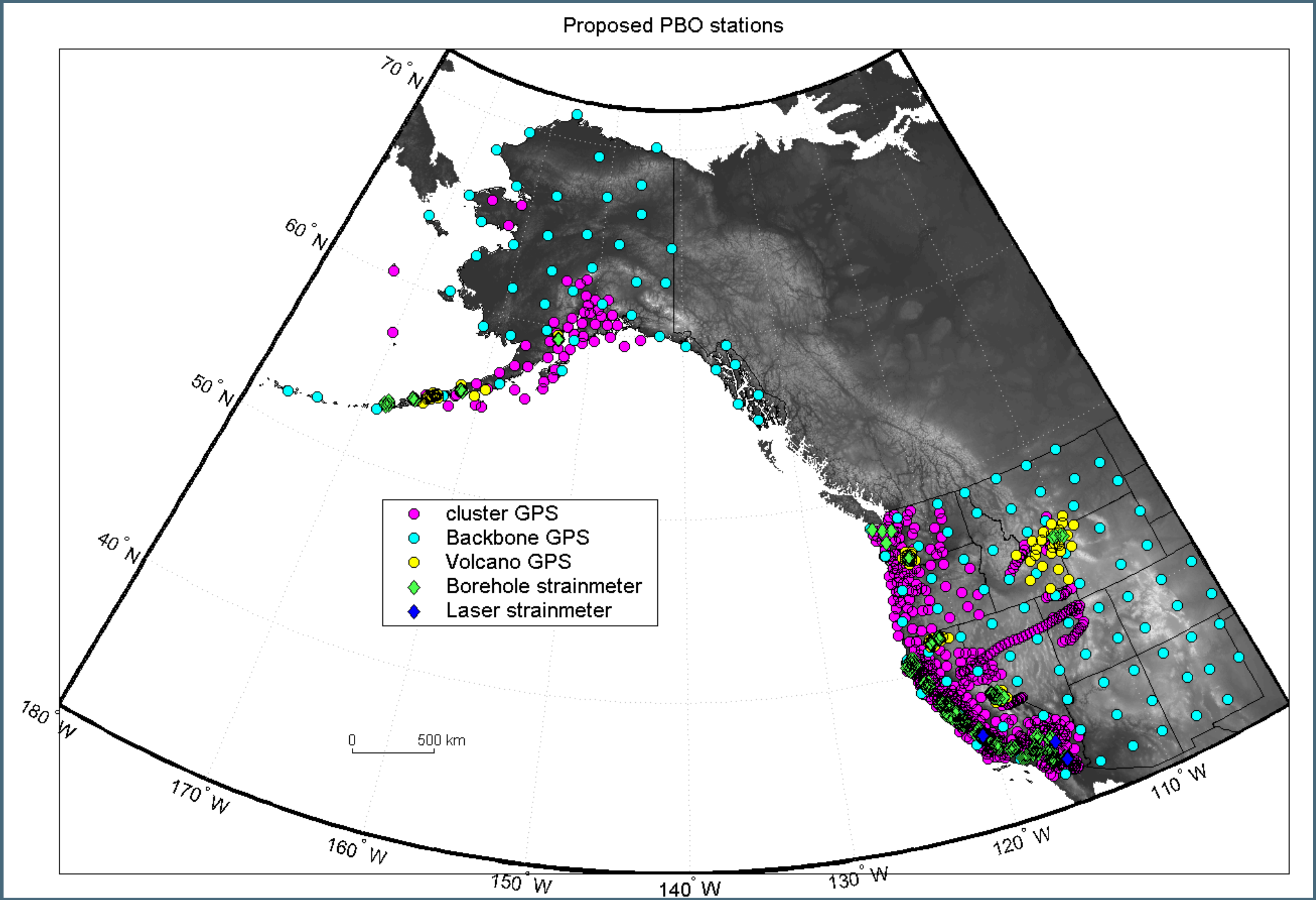
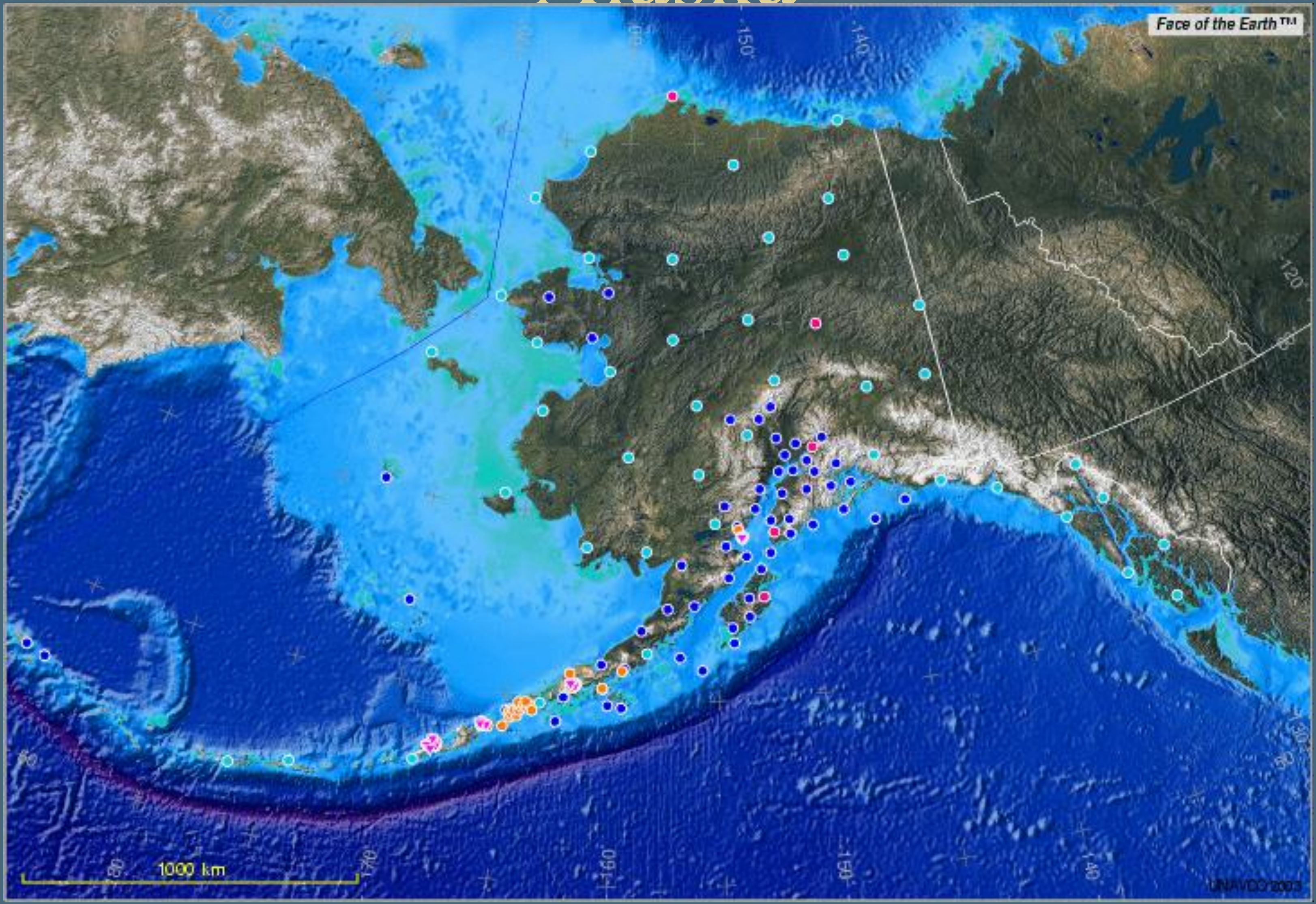

Proposed PBO stations
70° N
60° N
50° N
40° N
180° W
170° W
160° W
150° W
140° W
130° W
120° W
110° W
cluster GPS
Backbone GPS
Volcano GPS
Borehole strainmeter
Laser strainmeter
0
500 km

PBO Science/Directions

- Science Goals
  - What are the forces that drive plate-boundary deformation?
  - What determines the spatial distribution plate-boundary deformation?
  - How has plate-boundary deformation evolved?
  - What controls the space-time pattern of earthquake occurrence?
  - How do earthquakes nucleate?
  - What are the dynamics of magma rise, intrusion, and eruption?
  - How can we reduce the hazards of earthquakes and volcanic eruptions?
- Choice in Instrumentation
  - Capture signals with periods ranging from seconds to decades
- Deployment Strategy
- Role of Geological Component

Alaska



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Existing W. US

Only includes networks installed for geophysical research. Includes some but not all CORS.

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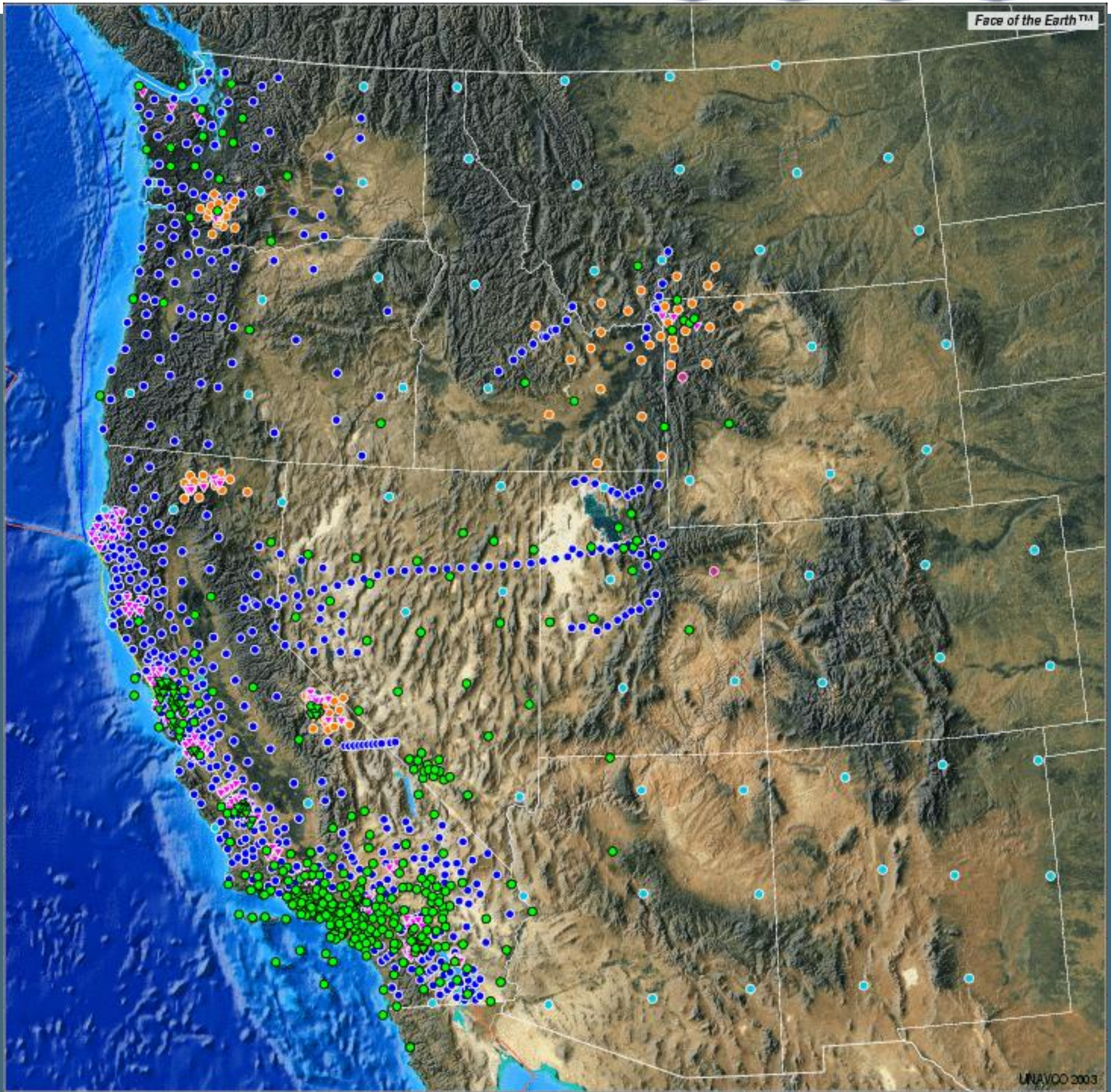
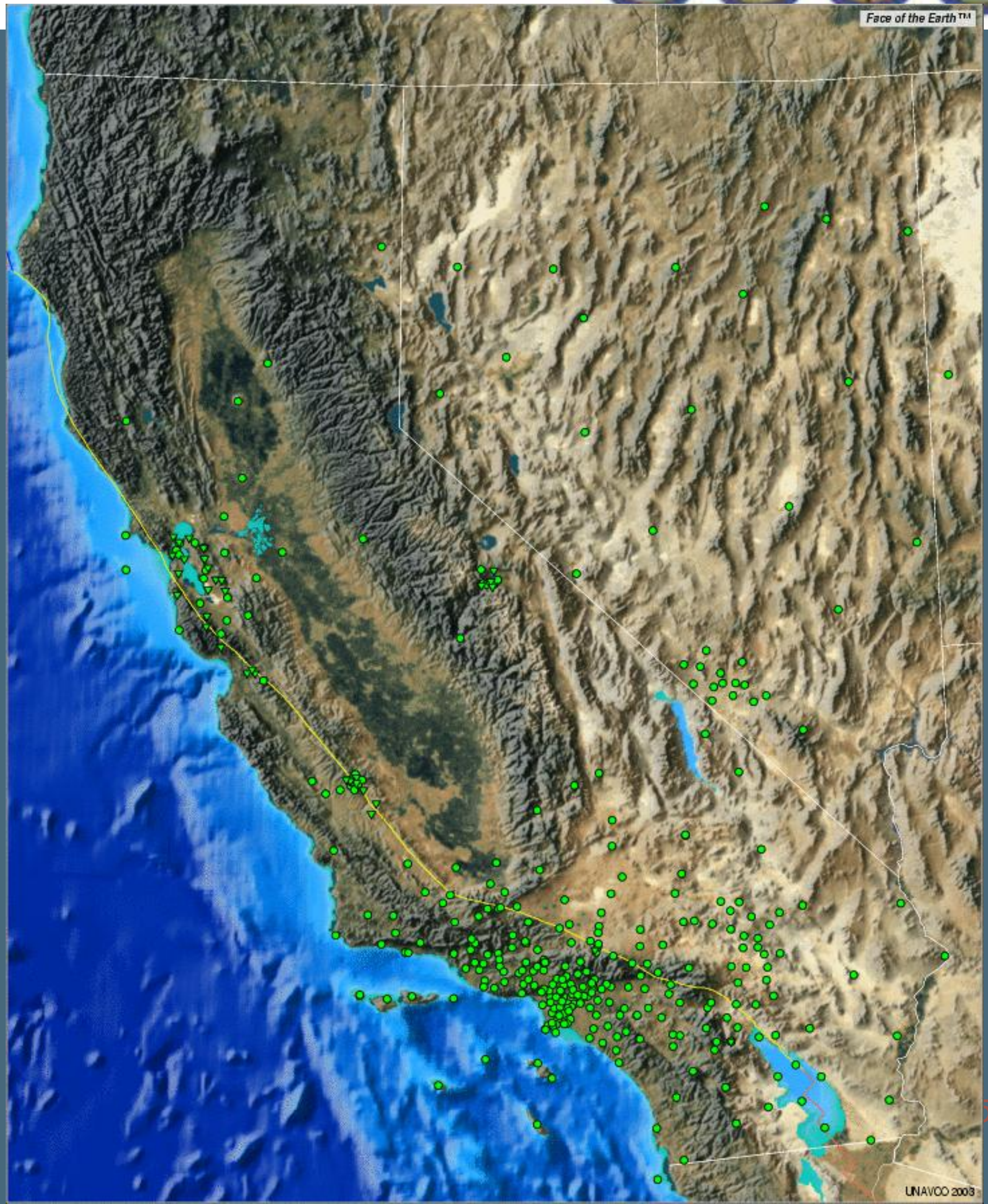
Existing W. US

+ New



Existing California



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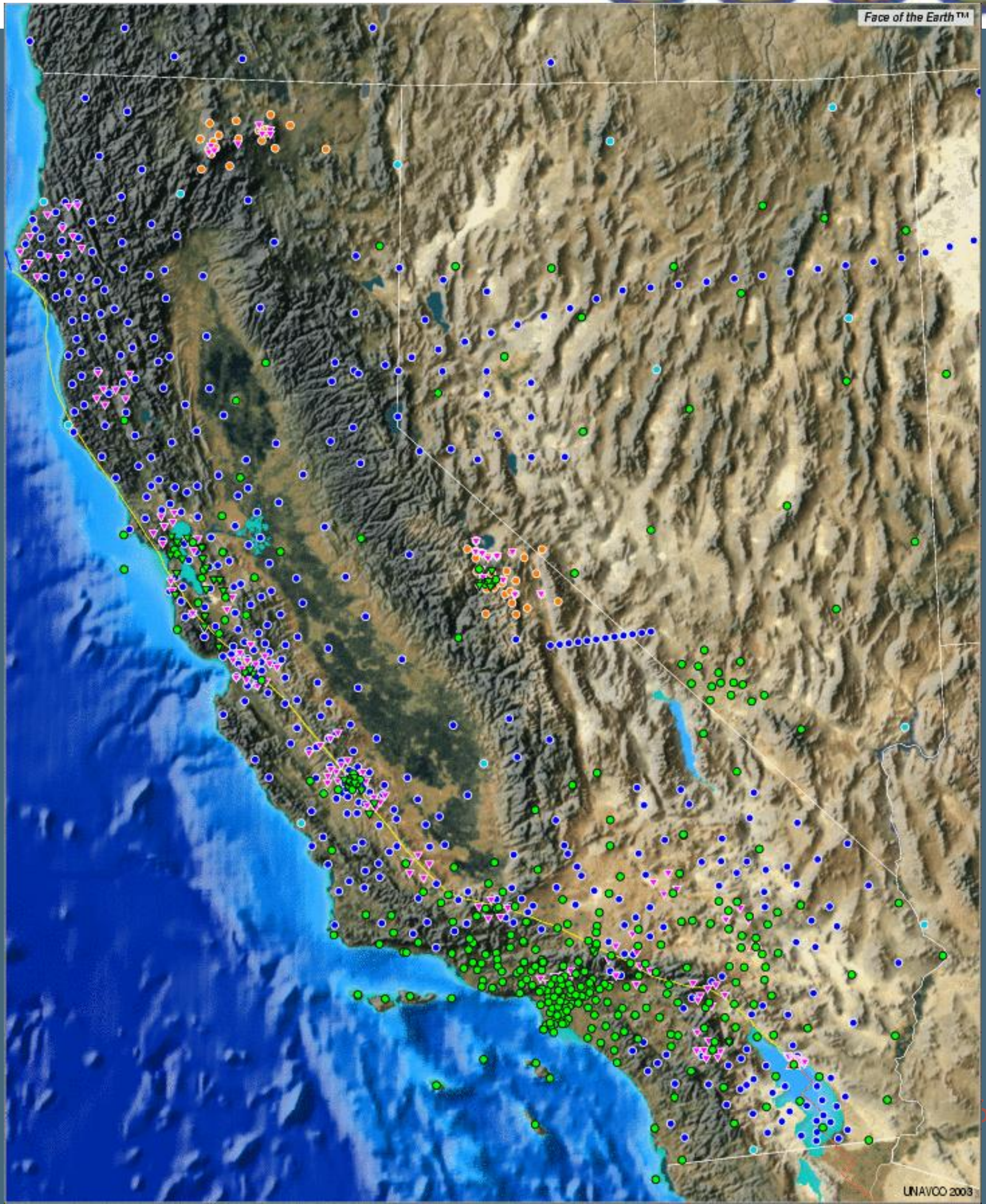
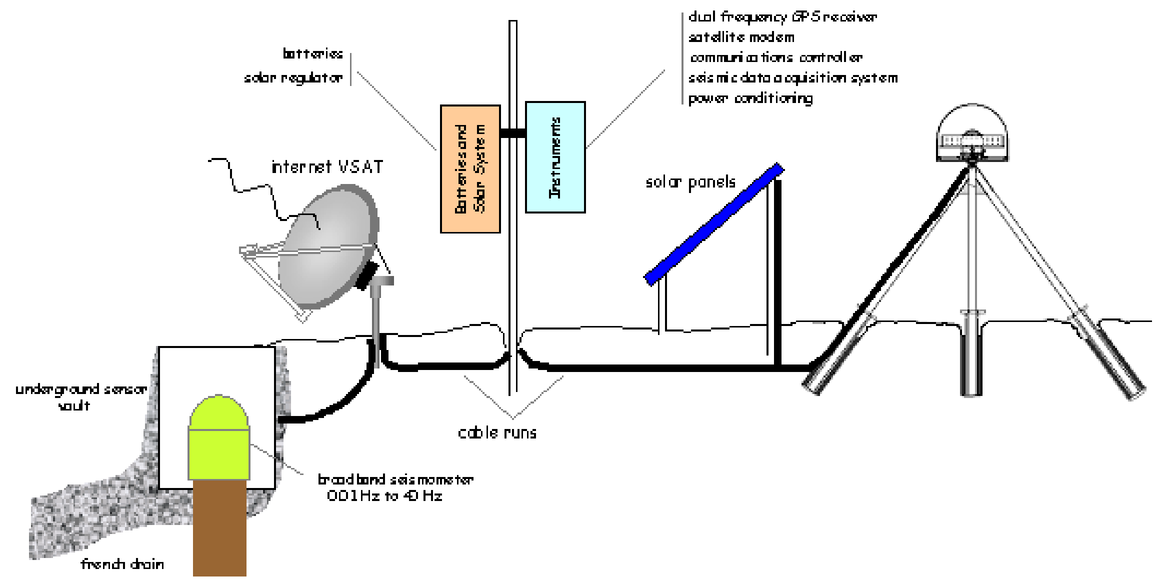
Existing California

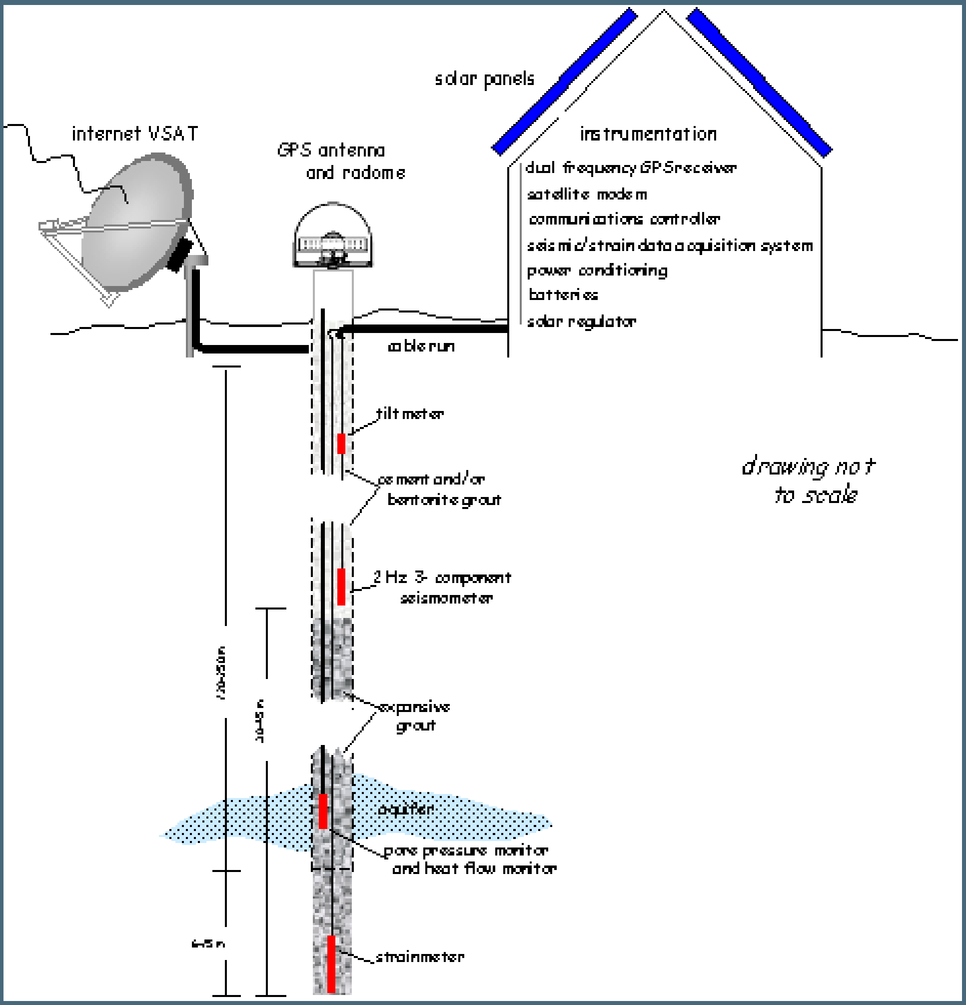
+ New



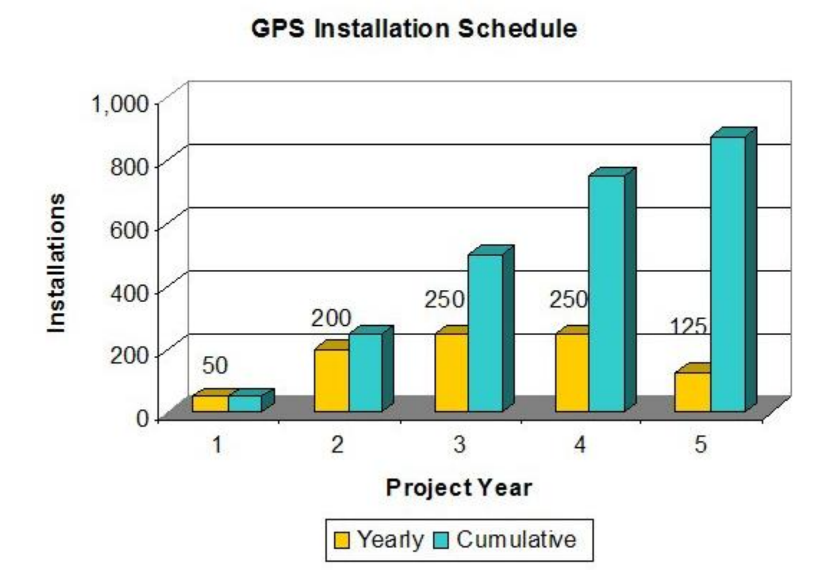
- GPS
  - Low power GPS receivers and Choke Ring antennas
  - Deep and Short-drill braced monuments. Others on case-by-case basis.
  - Power – DC solar option for wind.
  - Telemetry – combination of direct and satellite internet, microwave, and radio modem. VSAT and radio proposed for Aleutians.
  - GPS collocated at all strainmeter sites.
  - Some sites broadband seismometer ready.

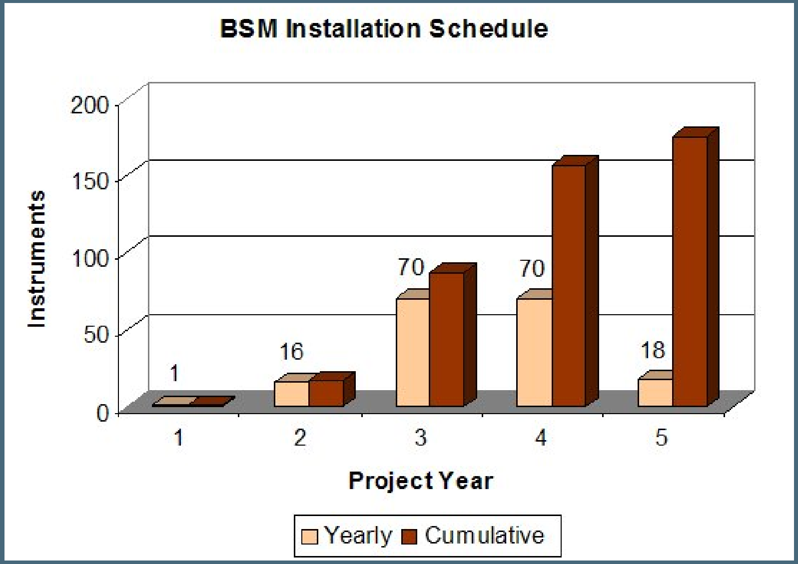


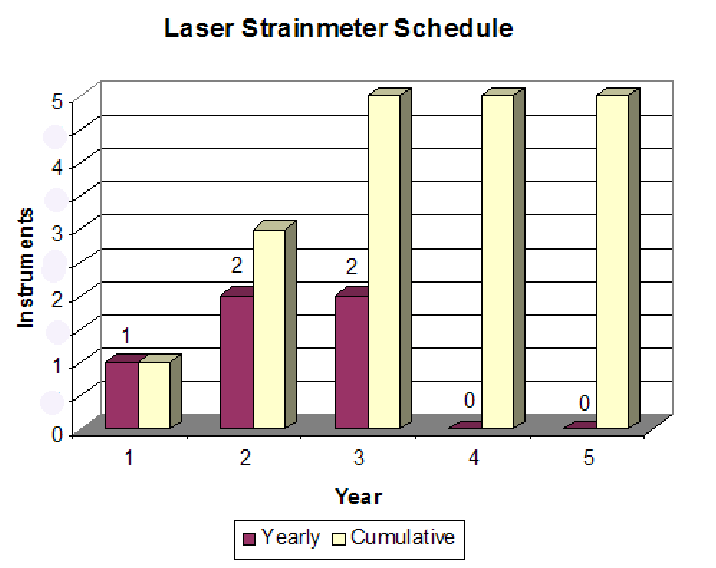
- Strainmeters
  - Borehole systems a combination of Sacks-Evertsen dilatometers and Gladwin Tensor Strain instruments installed in cluster of 4 or 5.
  - Borehole systems have 3-component, 2-Hz, borehole seismometer possible upgrade to 3-component broadband sensor.
  - Borehole systems have tiltmeter, GPS, pore pressure & heat flow monitors
  - GPS collocated at all strainmeter sites.
  - Propose using contract drilling managed by DOSECC



Installation Schedule







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What do these sites look like

- Two types of GPS installations proposed.
  - Low impact – hand drilled monuments, no heavy equipment
  - Moderate impact – track-mounted drill.
- One type of strainmeter installation proposed.
  - Requires drill rig capable of 8” hole to 600”.

Moderate impact GPS

Monument drilling

Monument installation

Final site

Low impact GPS

Monument drilling

Monument installation

Final site

Strainmeter

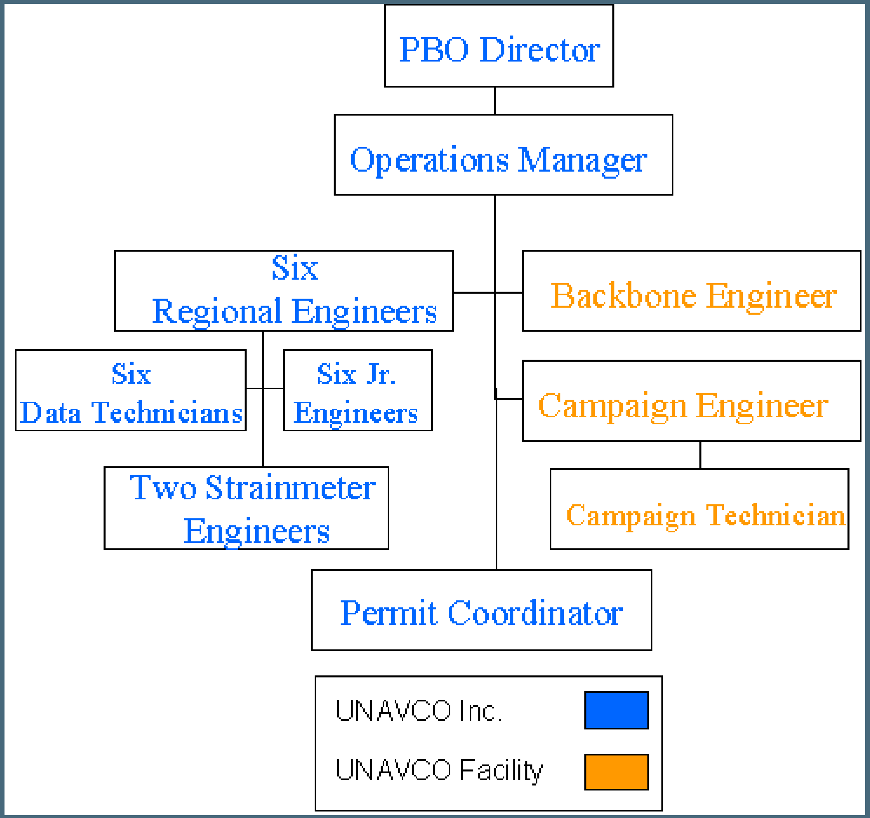
Borehole drilling

Strainmeter installation

Final site

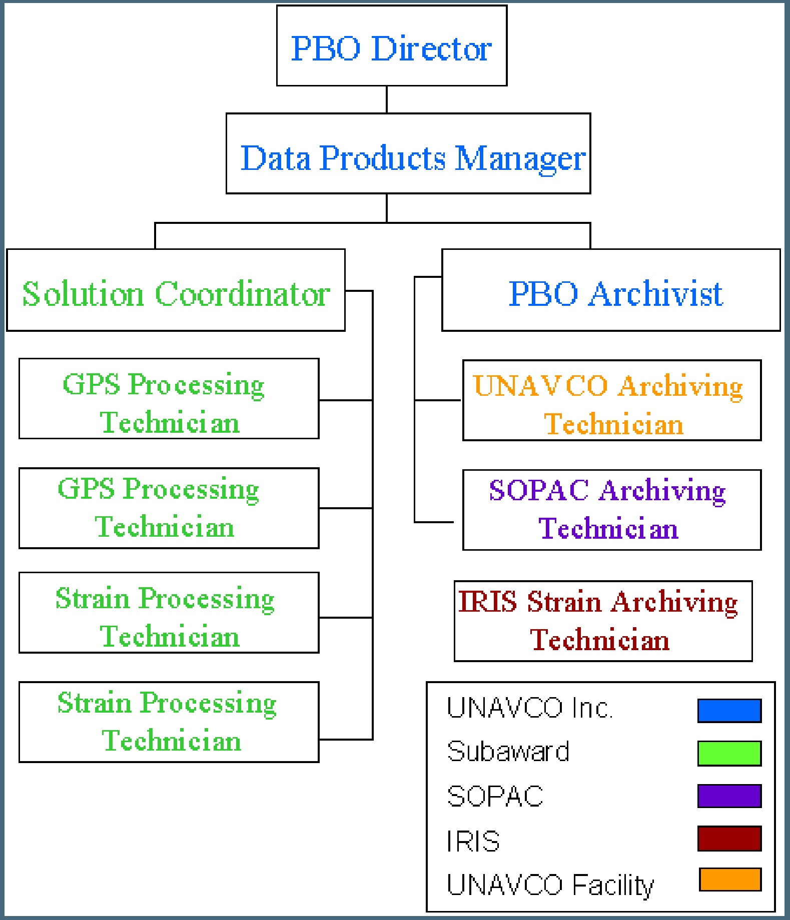
Operations Management

- Operations Manager oversees
  - 6 regional engineers, jr. engineers, and data techs.
  - 2 strainmeter engineers
  - Backbone engineer
  - Campaign engineer and tech
  - Permit coordinator



Data Management

- Data Products Manager oversees
  - PBO Archivist
  - SOPAC, UNAVCO, and IRIS archiving techs
  - Solutions Coordinator
  - 3 processing techs



Concluding Remarks

- For geophysical research, marks must be stable at the < 1 mm level for decades.
  - Requires good monuments, few antenna changes, good records on changes.
- To install ~1000 new geodetic stations over next five years will require help with:
  - Permitting
  - http://www.unavco.net/public/recon/submitinfo.aspx
  - People
  - http://www.unavco.net/public/careers/searchjobs.asp
- http://www.unavco.org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