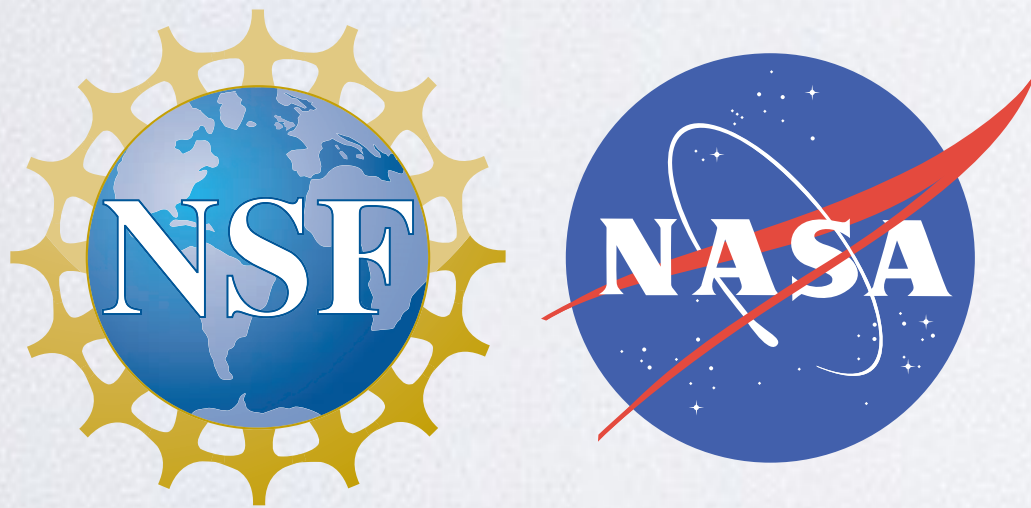


UNAVCO

UNAVCO UPDATE

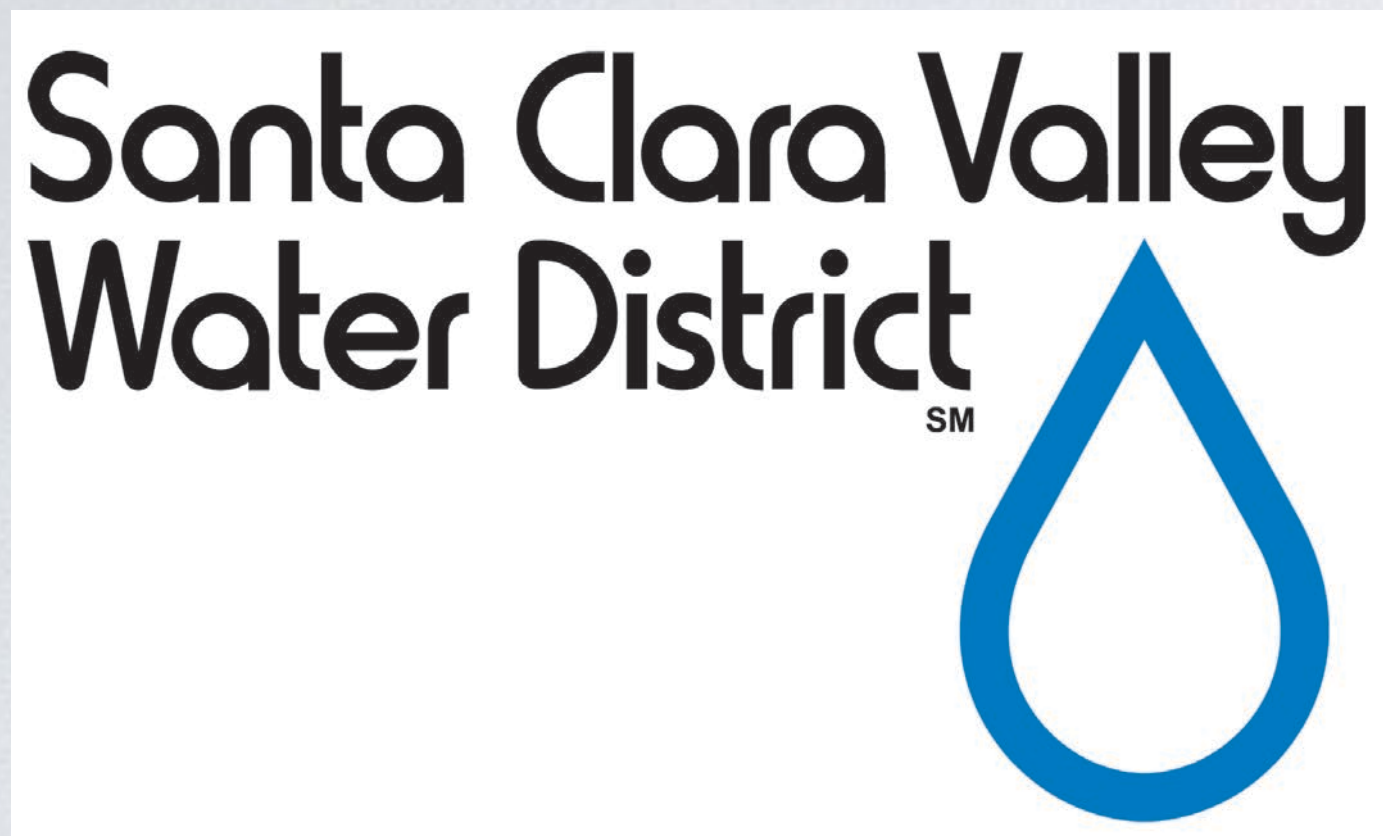
Chris Walls - Southwest Region



CSRC October, 2016 - Sacramento



THANK YOU PARTNERS



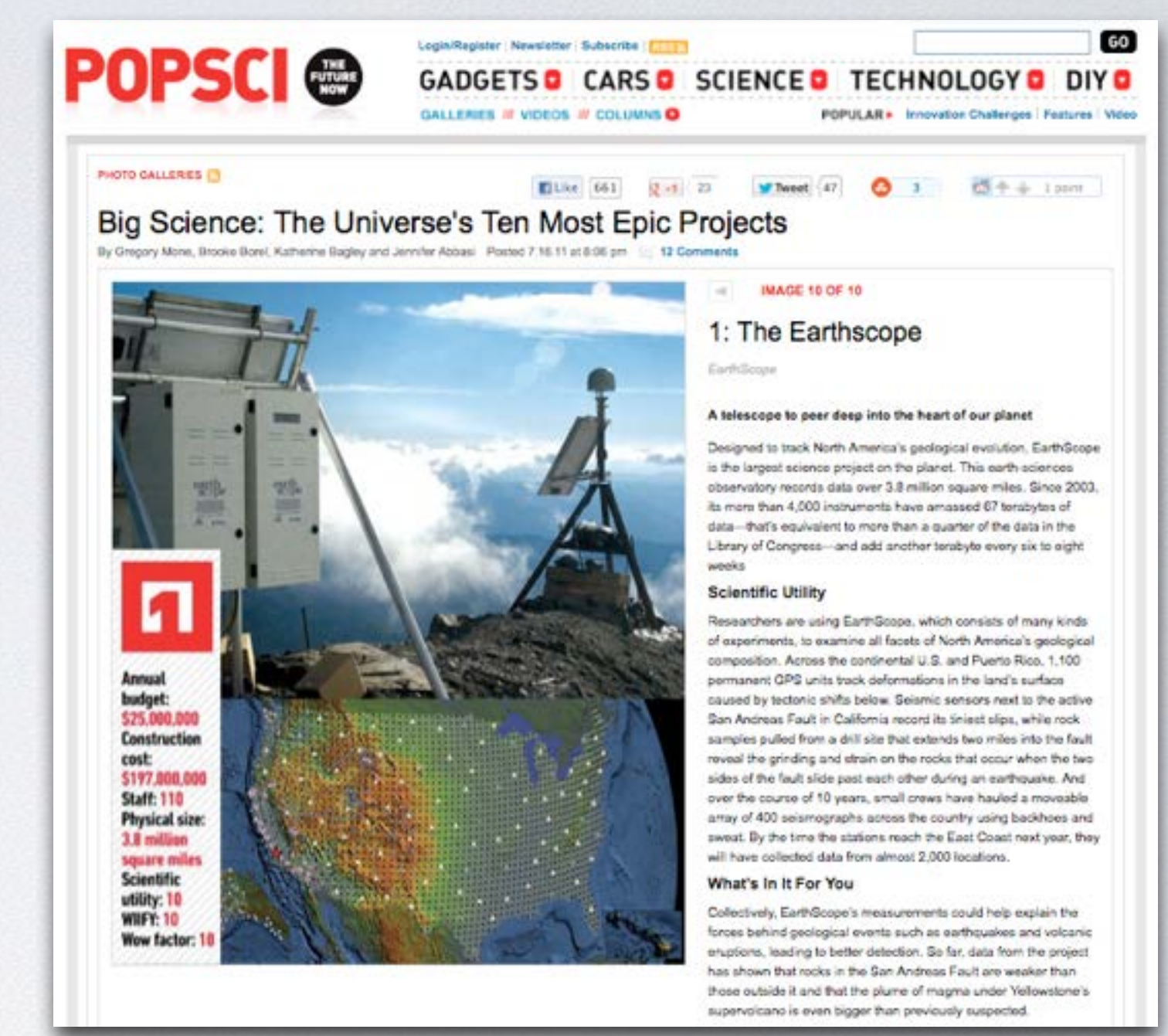


TALK OUTLINE

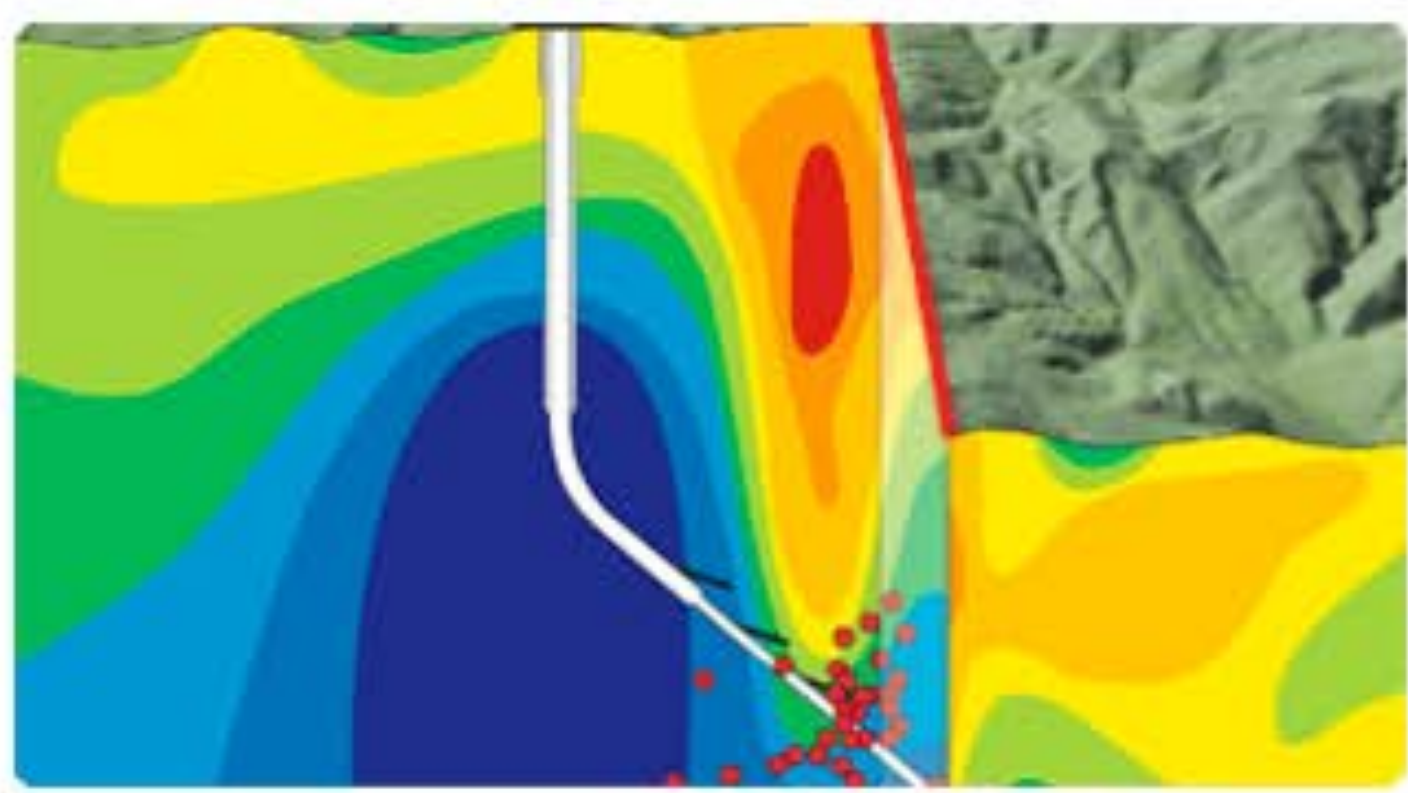
- Overview of UNAVCO GI program in NSF GAGE Facility: Infrastructure buildout, current status
- California Report: Current status, projects and vandalism
- Real Time: Latency, completeness, users
- Some Hope - NGE0: National Geophysical Observatory

EarthScope Background

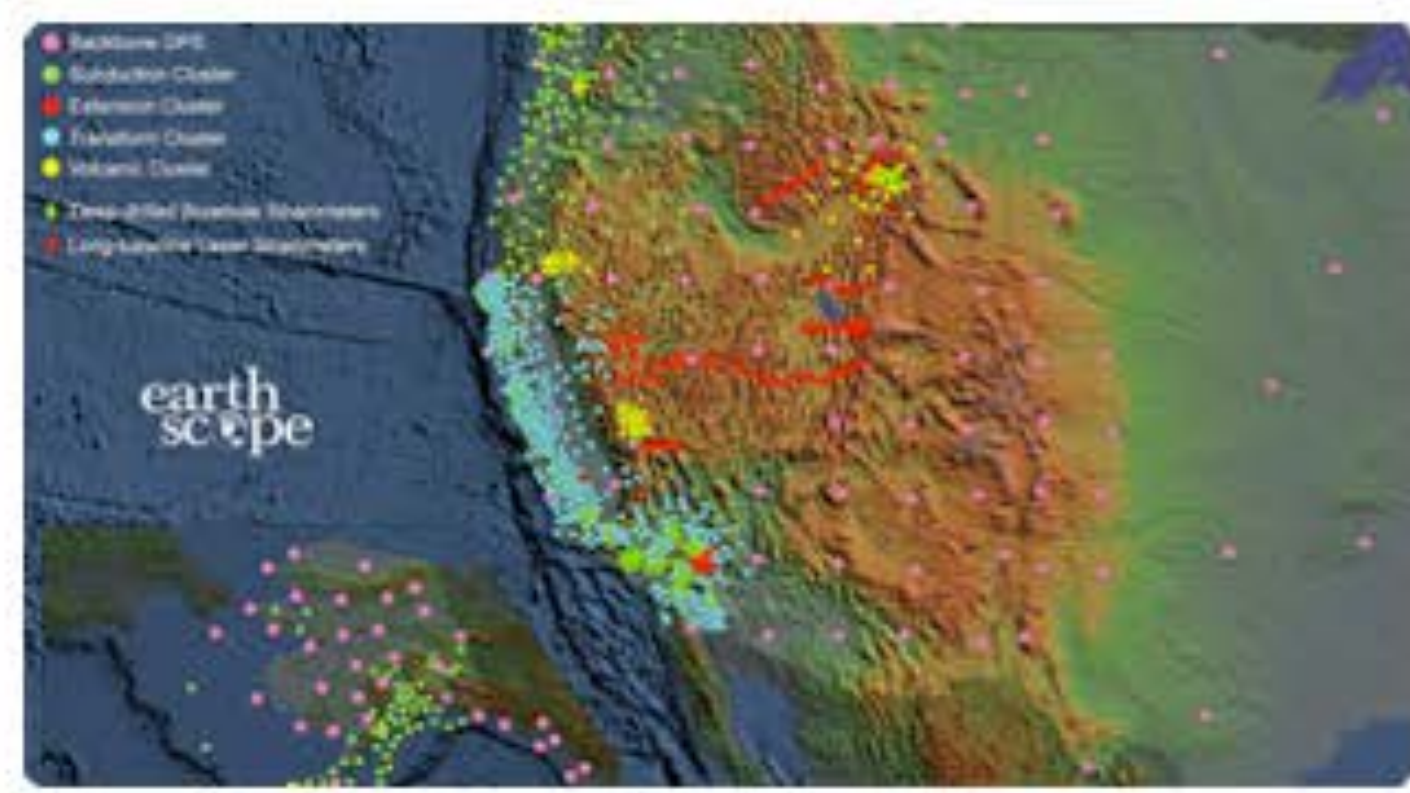
- **Funded by NSF**
- **Project started in 2003 - continues through 2018**
 - Three Components - Geodetic, Seismic, and Drilling
 - Deploys thousands of seismic, GPS, and other geophysical instruments
 - Purpose: To study the structure and evolution of the North American continent and the processes the cause earthquakes and volcanic eruptions.
 - A collaboration between scientists, educators, policy makers, and the public to learn about and utilize exciting scientific discoveries as they are being made.
- **Total EarthScope Budget: ~\$500M over the lifetime of the project**



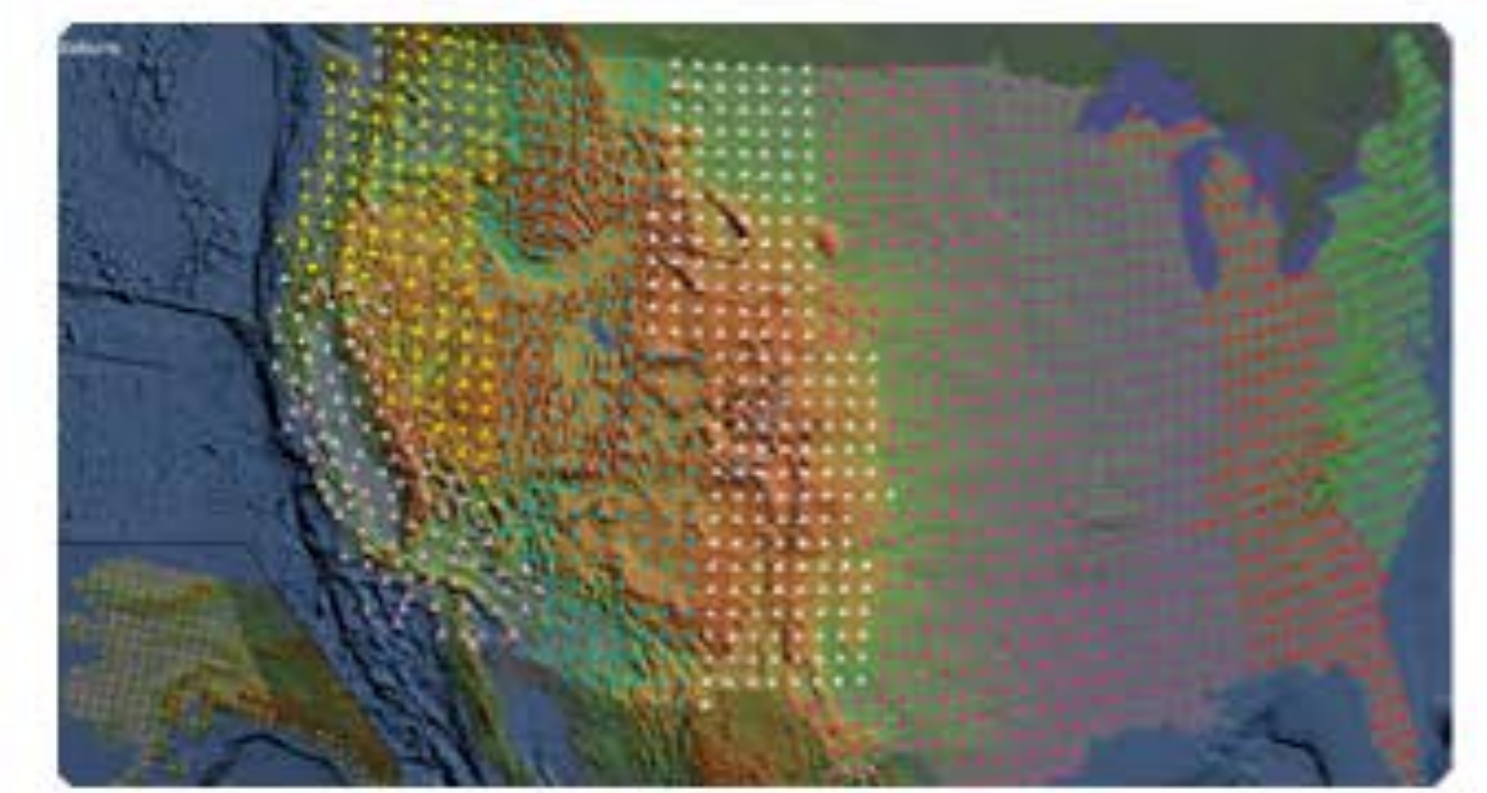
Drilling Component - SAFOD



Geodetic Component - PBO



Seismic Component - USArray



The Plate Boundary Observatory

Focused, dense deployments of cGPS and strainmeter arrays

- 1100 continuous Global Positioning Systems around tectonic clusters
- 78 borehole strainmeters
- 5 long baseline strainmeters
- 26 tiltmeters
- 100 meteorological instruments

Portable GPS receivers

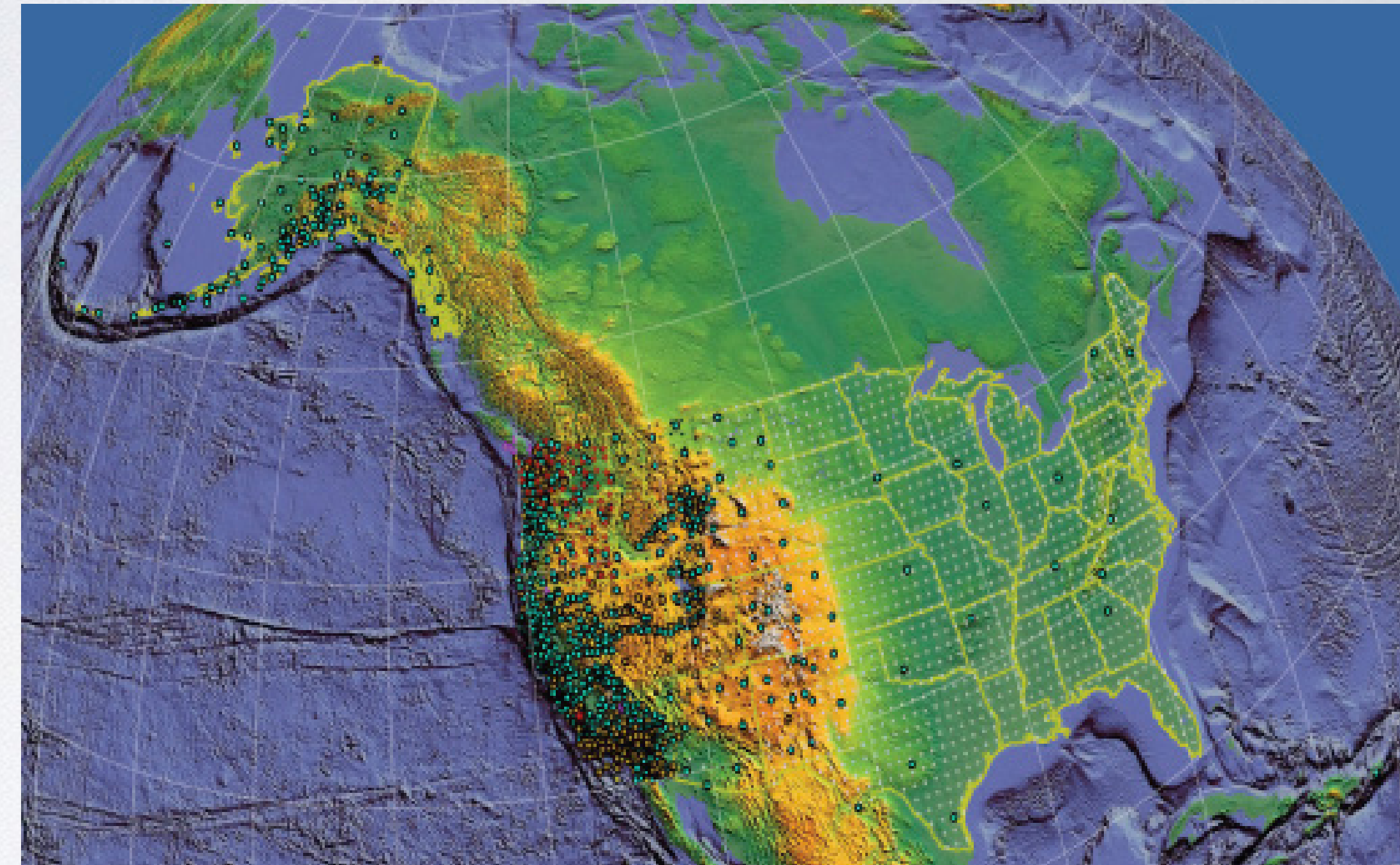
- Pool of 100 portable GPS receivers for temporary deployments to areas not sufficiently covered by continuous GPS

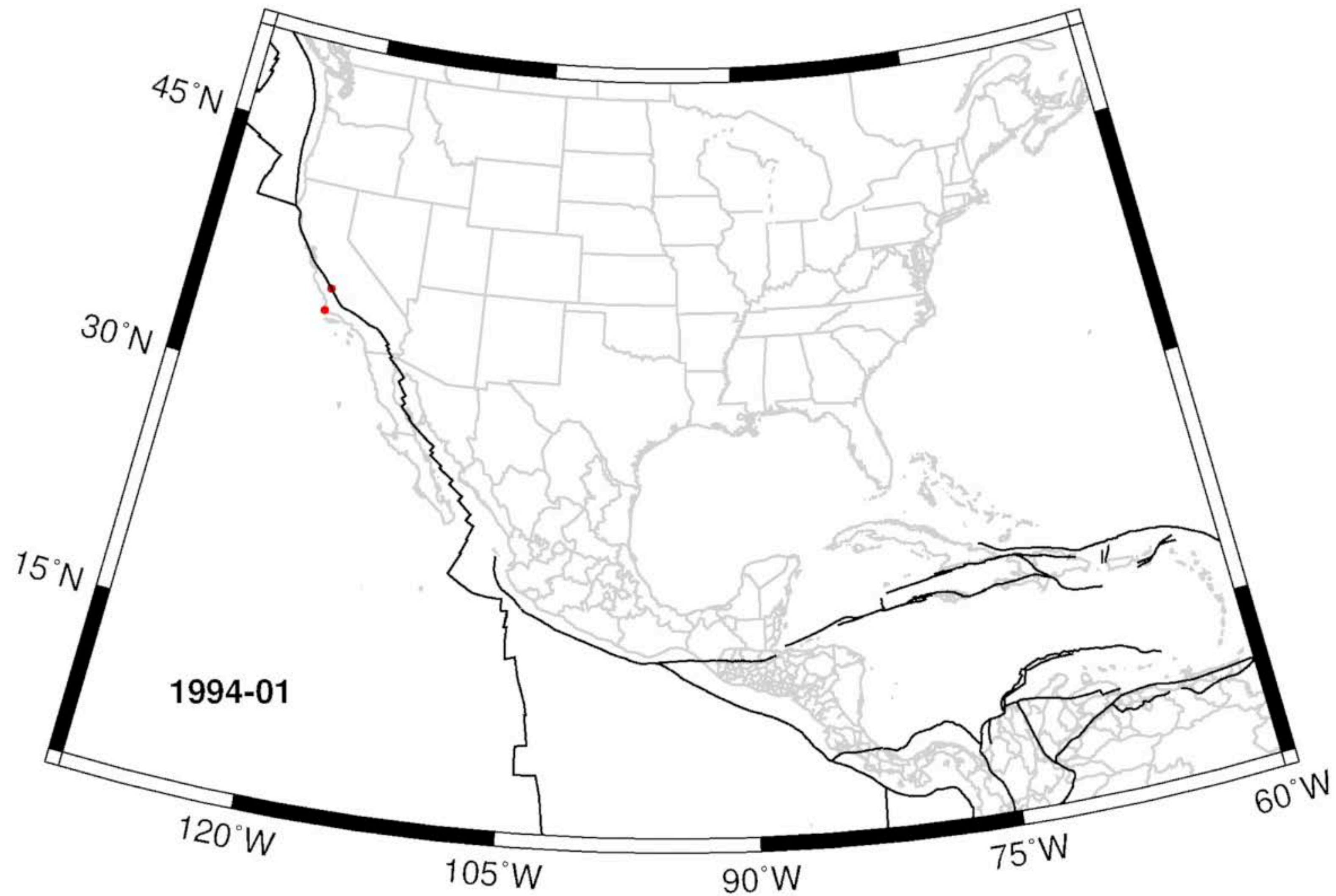
Geo-EarthScope

- InSAR imagery covering the western US
- LIDAR imagery covering the northern and southern San Andreas Fault, Yellowstone Caldera, and faults in Cascadia and Alaska

Network Costs

- \$100M - Construction Phase (2003-2008)
- \$54M - Operations and Maintenance Phase I (2009-2013)
- \$46M - Operations and Maintenance Phase 2 (2014-2018)

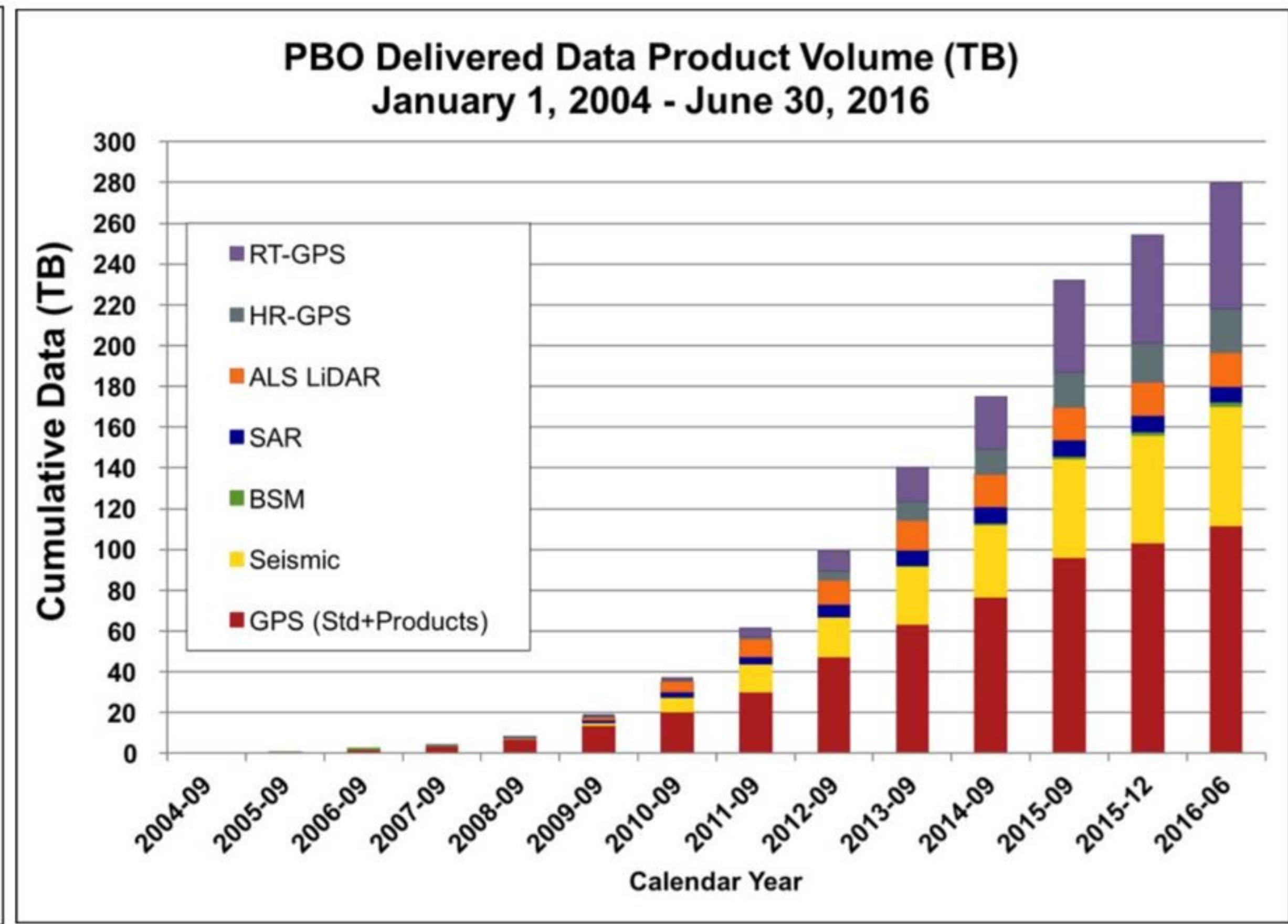
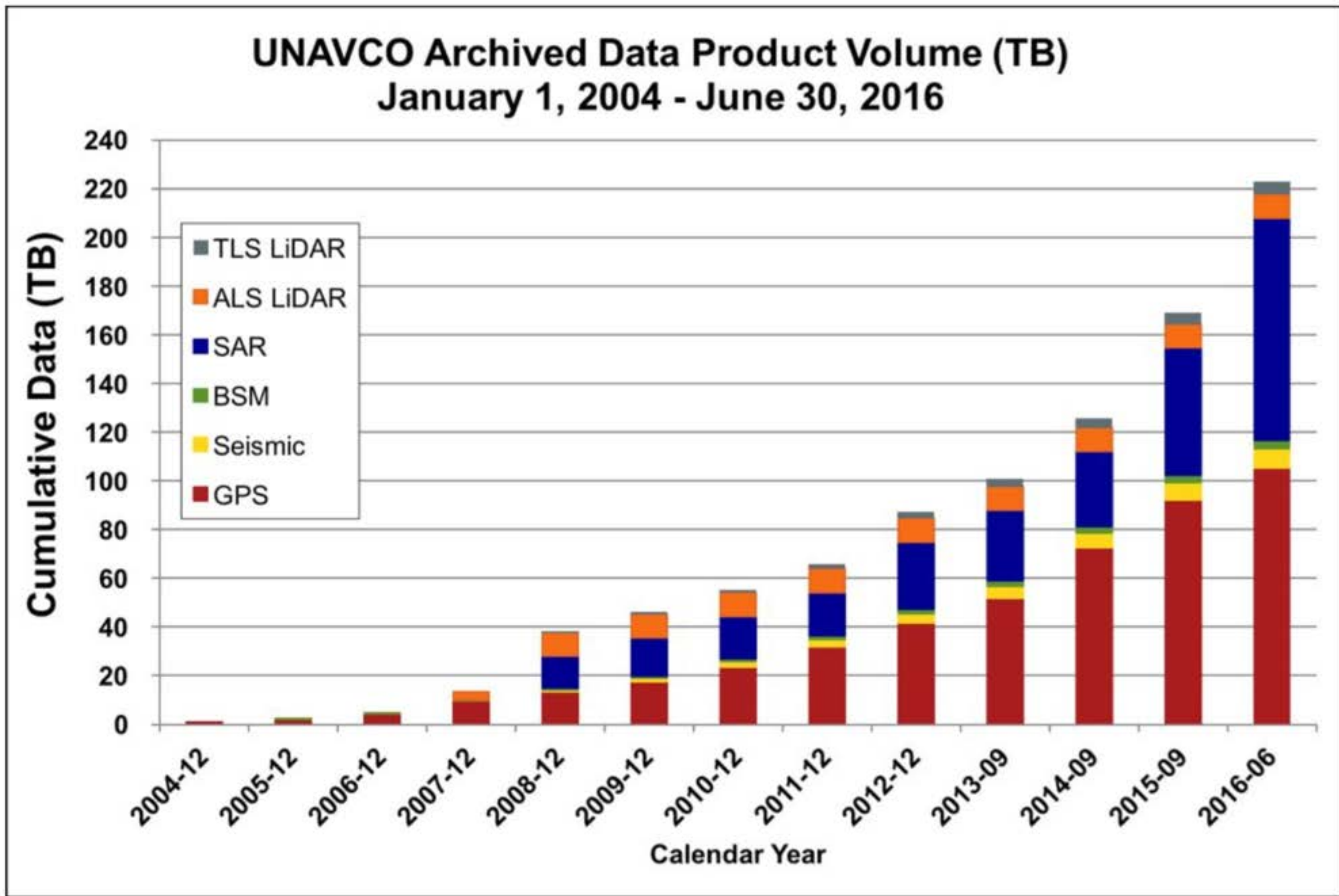




As of 10:51 a.m. Today - Animations by D. Mencin, UNAVCO

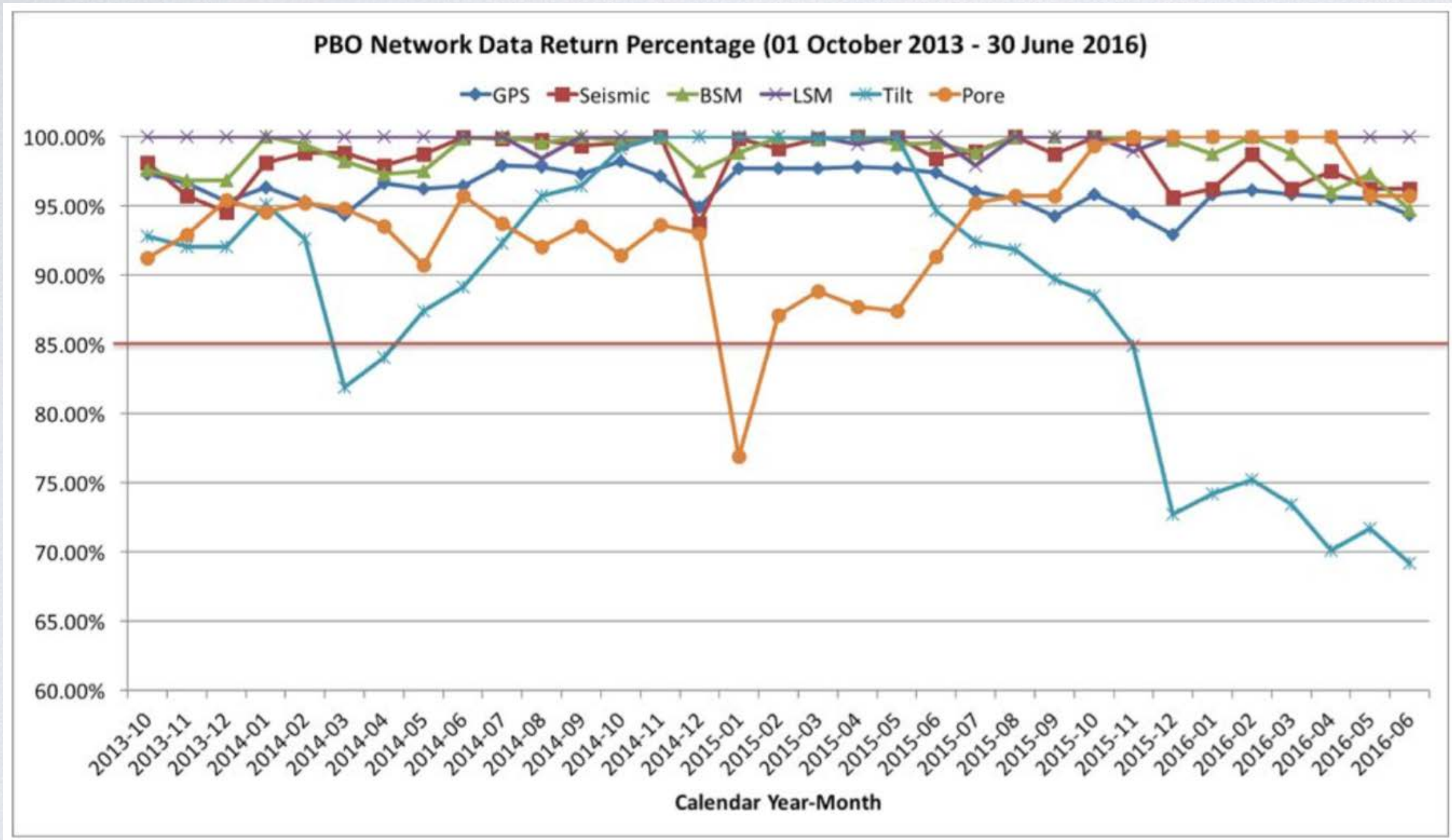


PBO DATA ARCHIVED & DELIVERED





PBO SENSOR DATA RETURN - 96% GPS-NETWORK-WIDE



Cumulative data return for the PBO network since the beginning of the O&M period (FY2009) is:

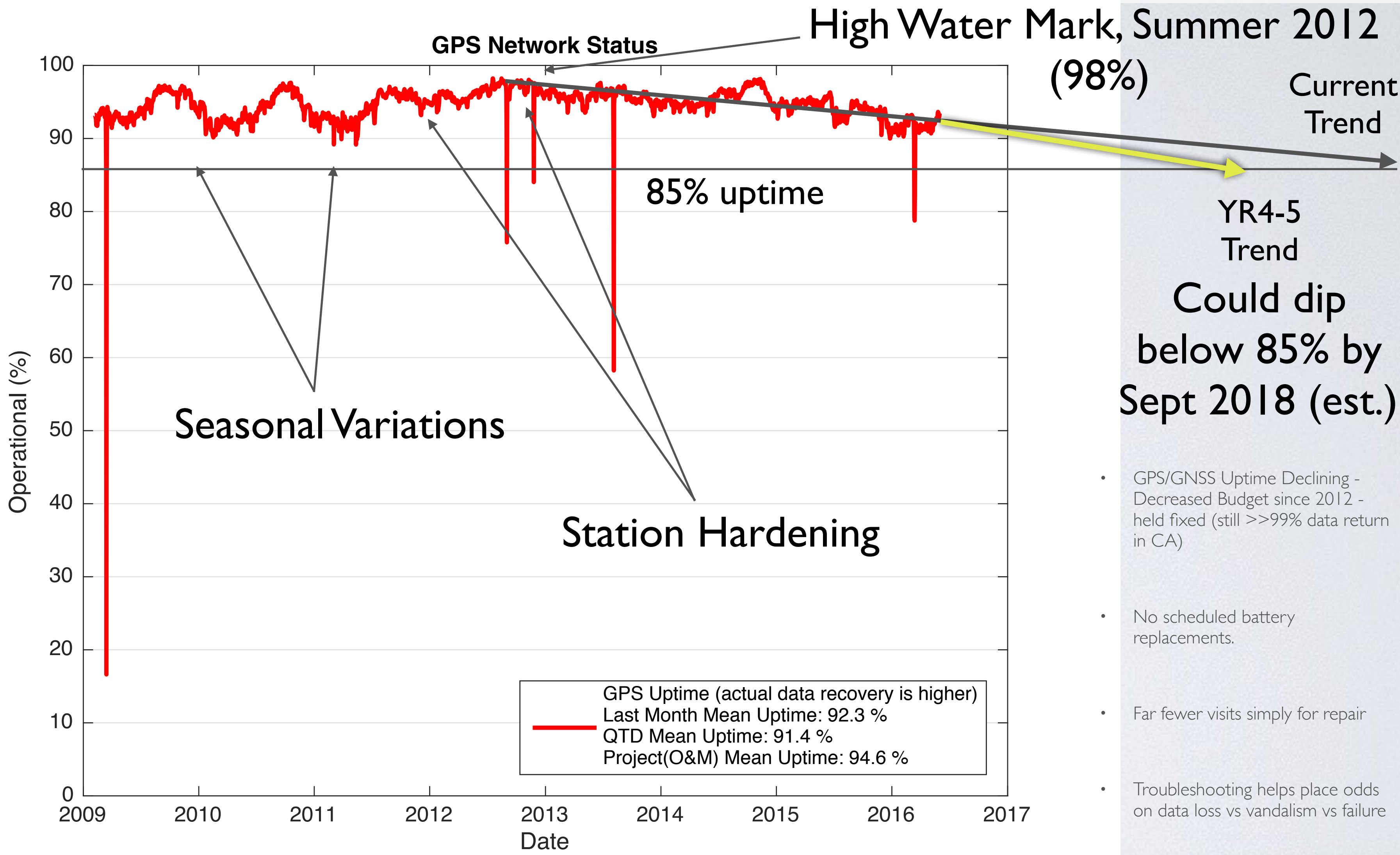
- 96% for GPS/Met (99% CA)
- 98% for seismic
- 99% for BSM
- 100% for LSM
- 94% for pore pressure
- 89% for tilt.

Metrics complete through June 30, 2016



GPS NETWORK UPTIME...GOING DOWN

Operational definition: a GPS station is considered “up” if less than 3 days have passed since data arrived in the archive



- GPS/GNSS Uptime Declining - Decreased Budget since 2012 - held fixed (still >>99% data return in CA)
- No scheduled battery replacements.
- Far fewer visits simply for repair
- Troubleshooting helps place odds on data loss vs vandalism vs failure

Community & Continuously Observing Networks

GPS/GNSS and Metpack Operations

NASA GGN

POLENET: GNET & ANET

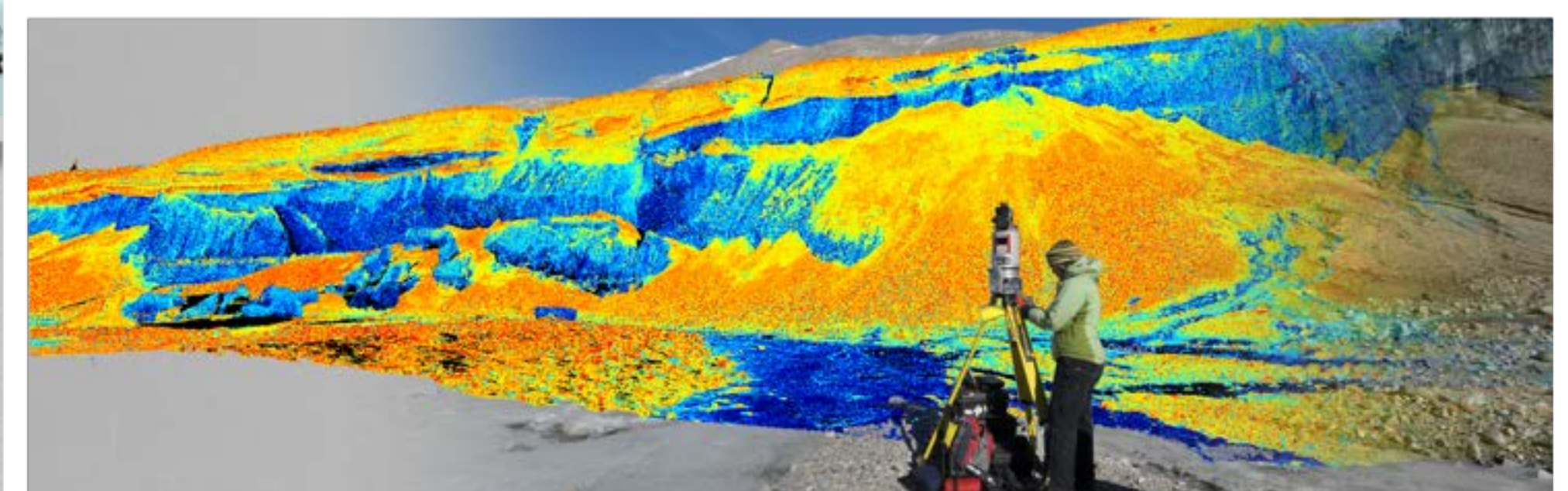
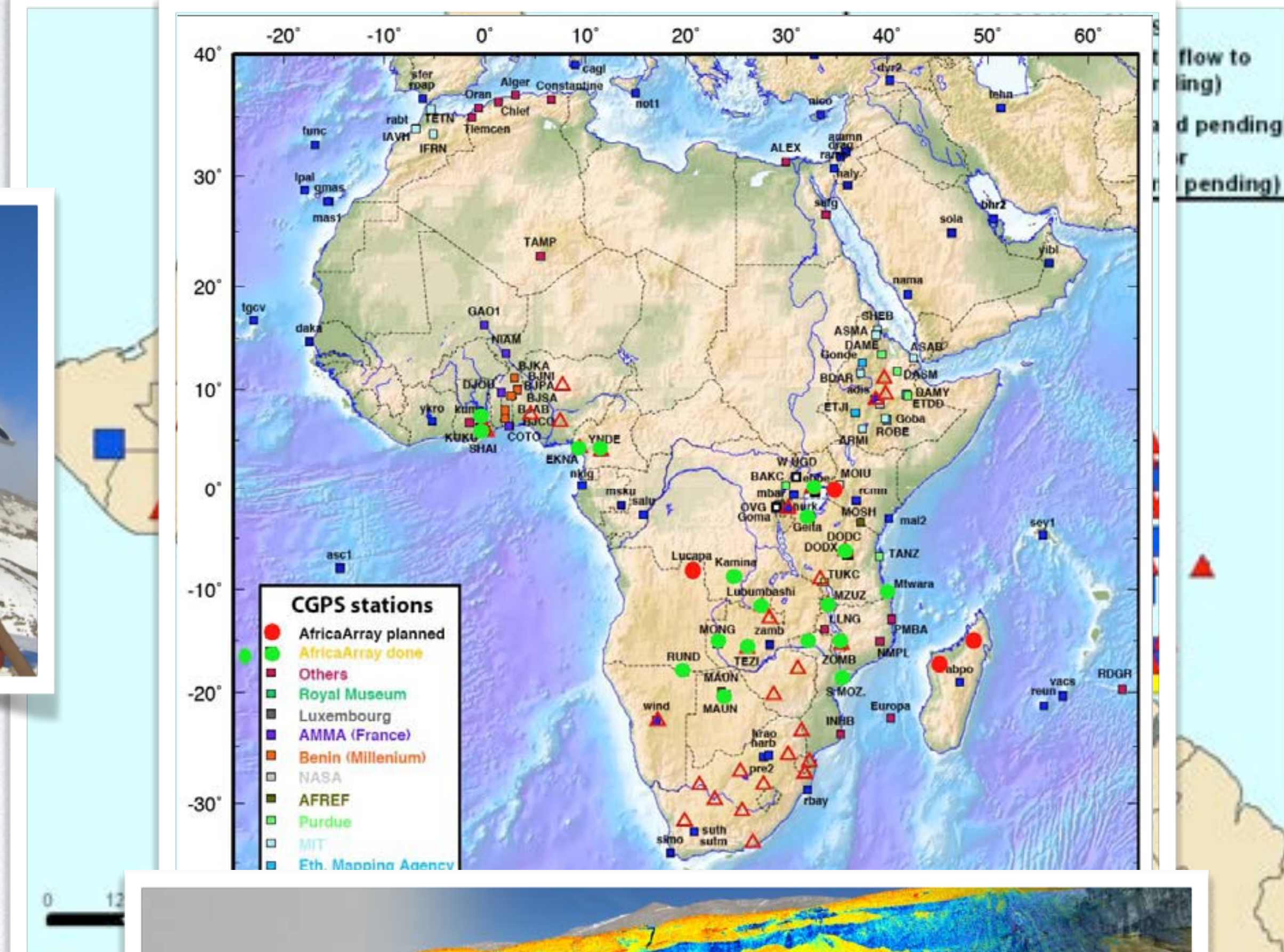
COCONet, TLALOCNet, and Africa Array

Principal Investigator support

Campaign and longer term GPS deployments

Terrestrial Laser Scanning Projects

Development & Testing





NASA GGN OPERATIONS



GGN Network Status

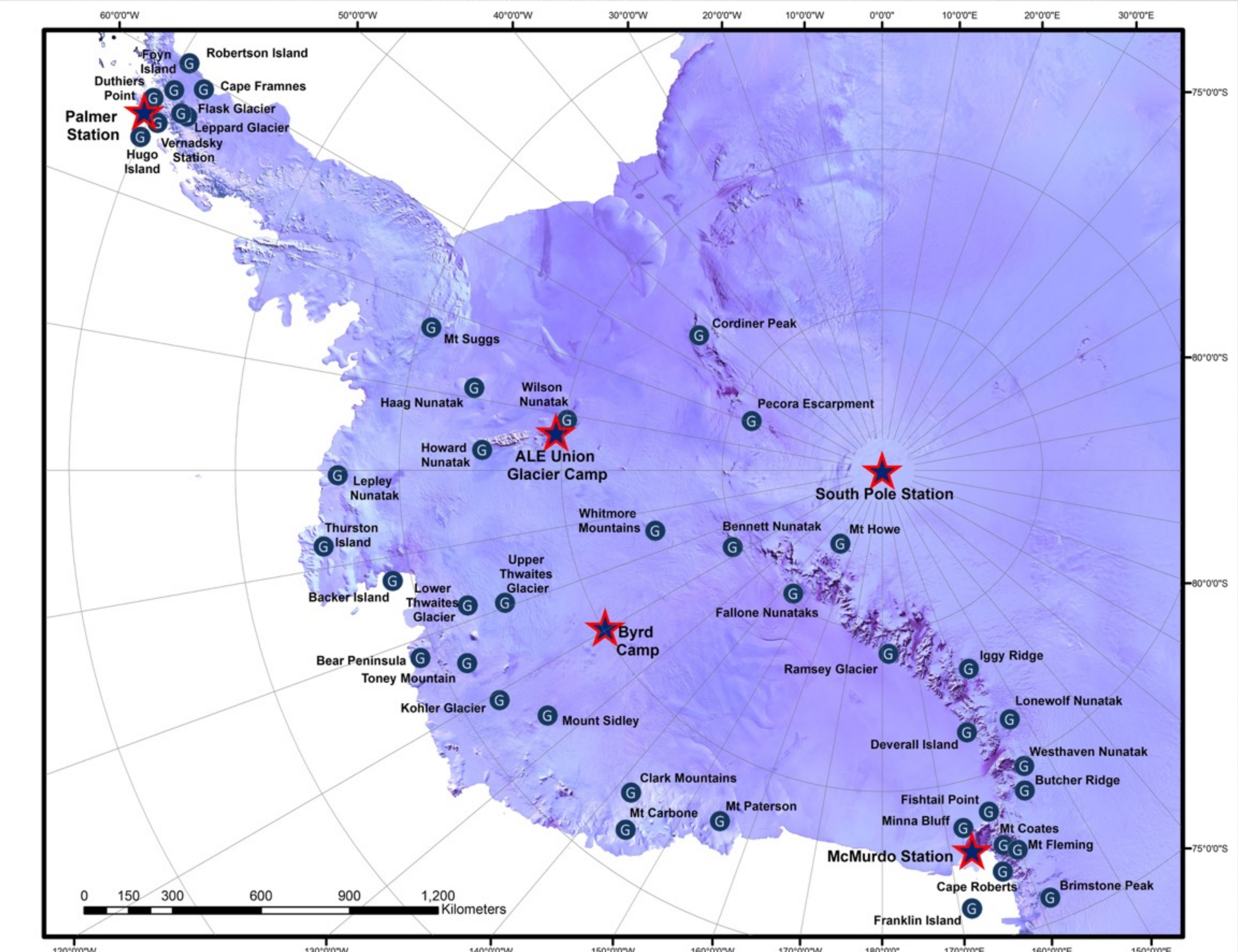
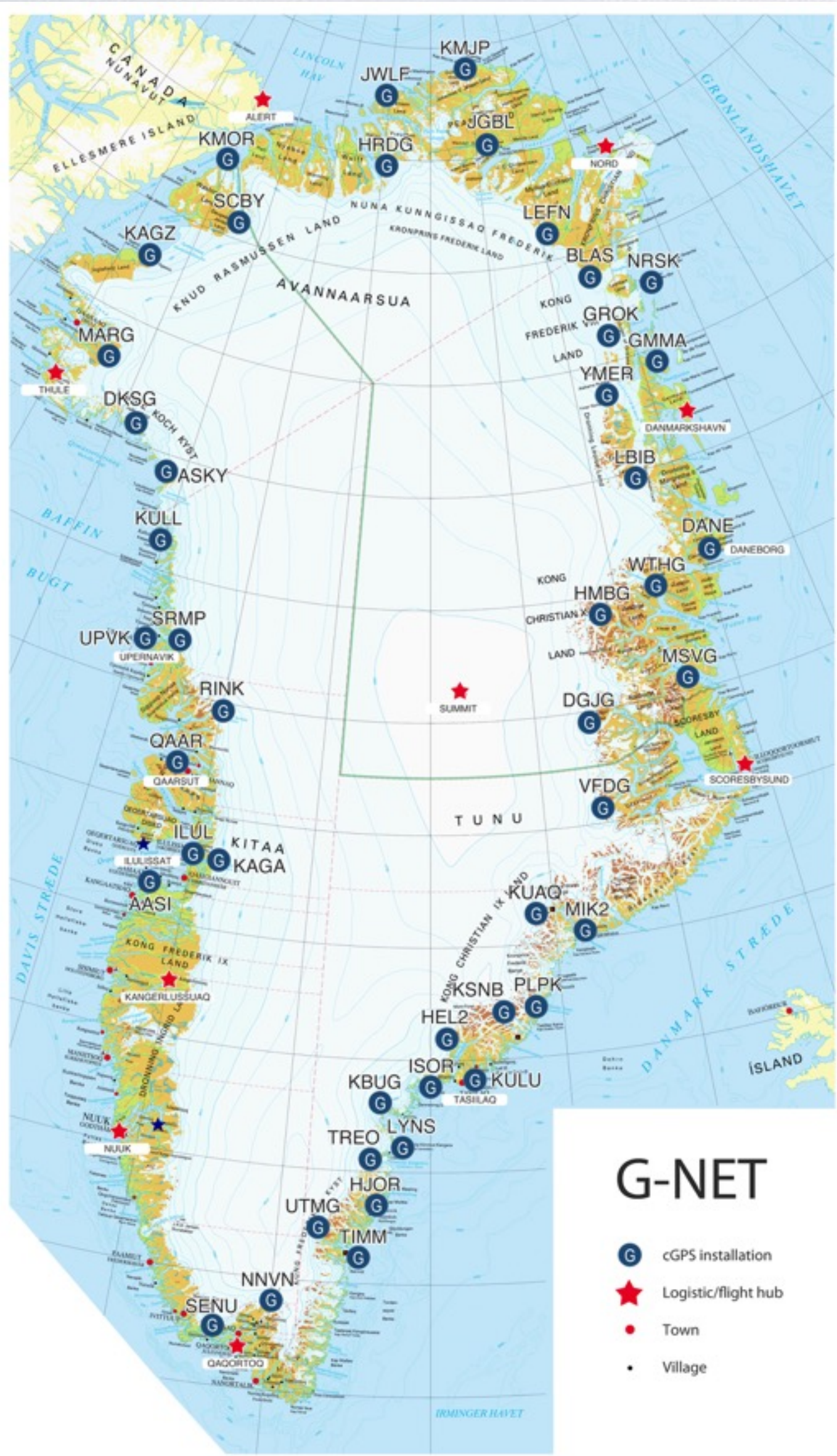
- 59 Global Stations - 88 Receivers
- 33 IGS Reference Frame Stations
- 28 Multi-GNSS capable
- 97 % network health

Recent Highlights

- Permits approved for NASA SGP Installations at McDonald, TX and Haleakala, HI. Installations planned for Q1 2016
- Satellite communications restored at MBAR, Uganda
- Communications upgrades at ABPO, Madagascar, and GLPS, Galapagos in progress
- Data communications to Harvest Platform, CA, a shared NOAA Sea Level Facility, are now reconfigured from VSAT to radio link to VNDP with PBO collaboration



POLAR - POLENET





POLAR

- Seven Polar Services staff, including five engineers, one technician.
 - Most deploy to Antarctica for 2-3 mo/yr.
 - Field work in the Arctic occupies 2-3 weeks at a time.
- Twenty four Antarctic projects supported this quarter;
 - 3 in the next quarter.
 - 6 UNAVCO staff deployed to support the Antarctic effort.
 - 27 Antarctic projects in total scheduled for 2015-16
- Current Station count:
 - ANET=45 stations, GNET=42 stations.
 - 89% data return. 94% of sites operational.



Mt. Erebus - January, 2016 - Photo Credit: J. Pettit, UNAVCO



TLALOCNET GPS-MET NETWORK

COMPLETED BETWEEN JULY 2014 - DECEMBER 2015

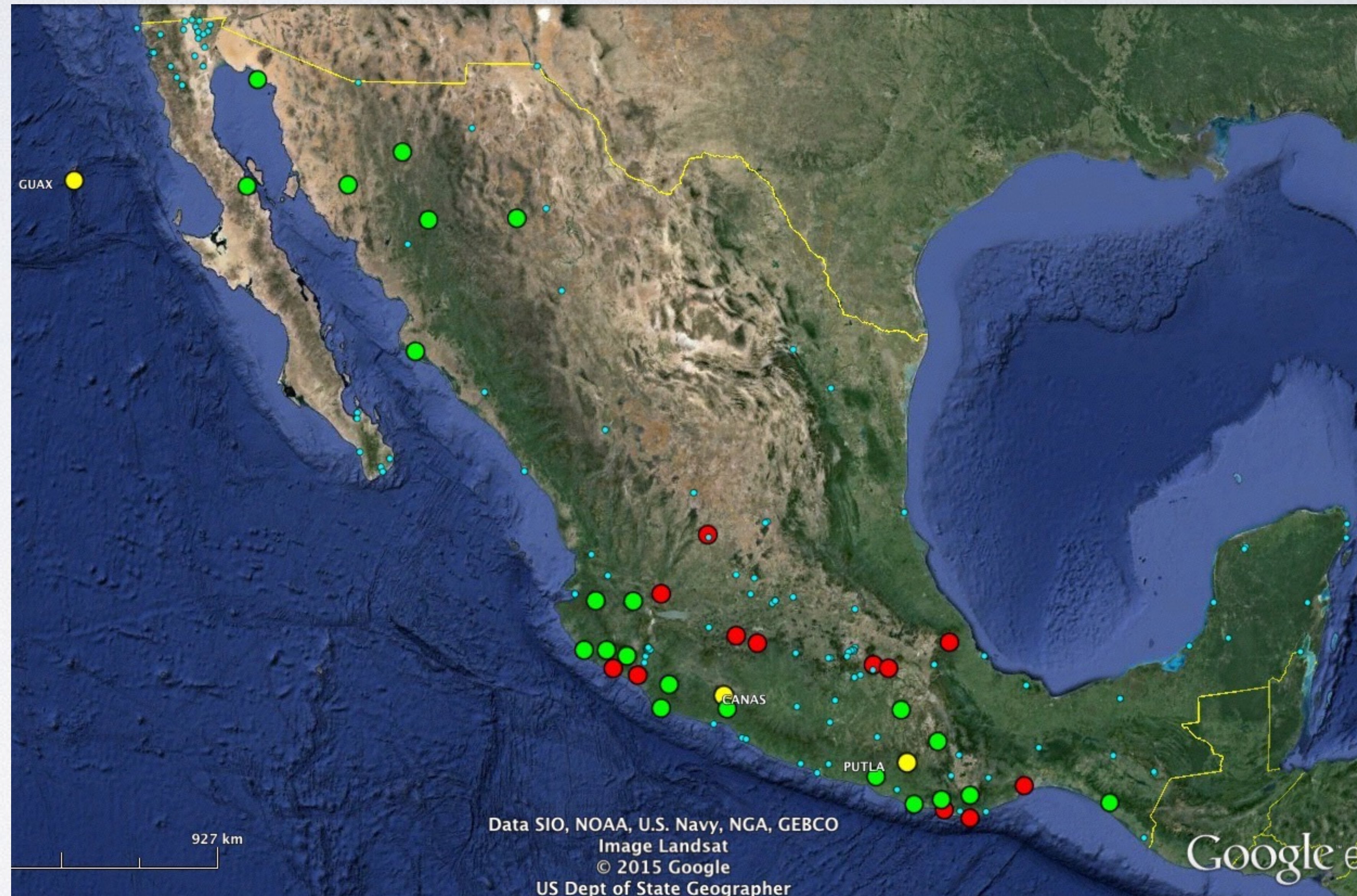
- 22 NSF stations (green), 12 UNAM stations (red).
- Regional Data Center @ Guadalajara

Completed 2016

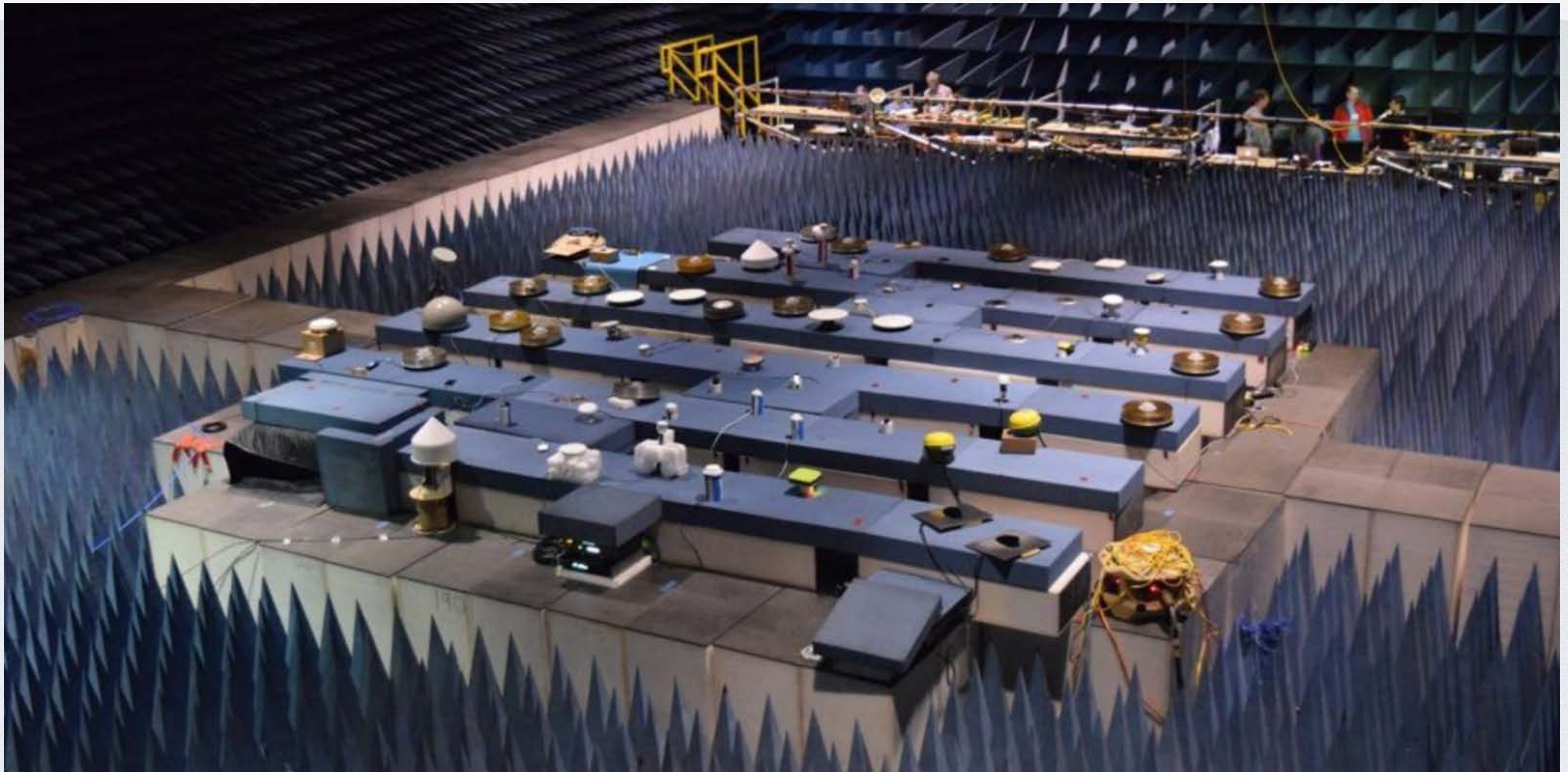
- Remaining 2 NSF stations (yellow), 1 UNAM station.
- Begin operations and maintenance.

BUDGET

- Projected to be 6% under budget at end of Year 3.

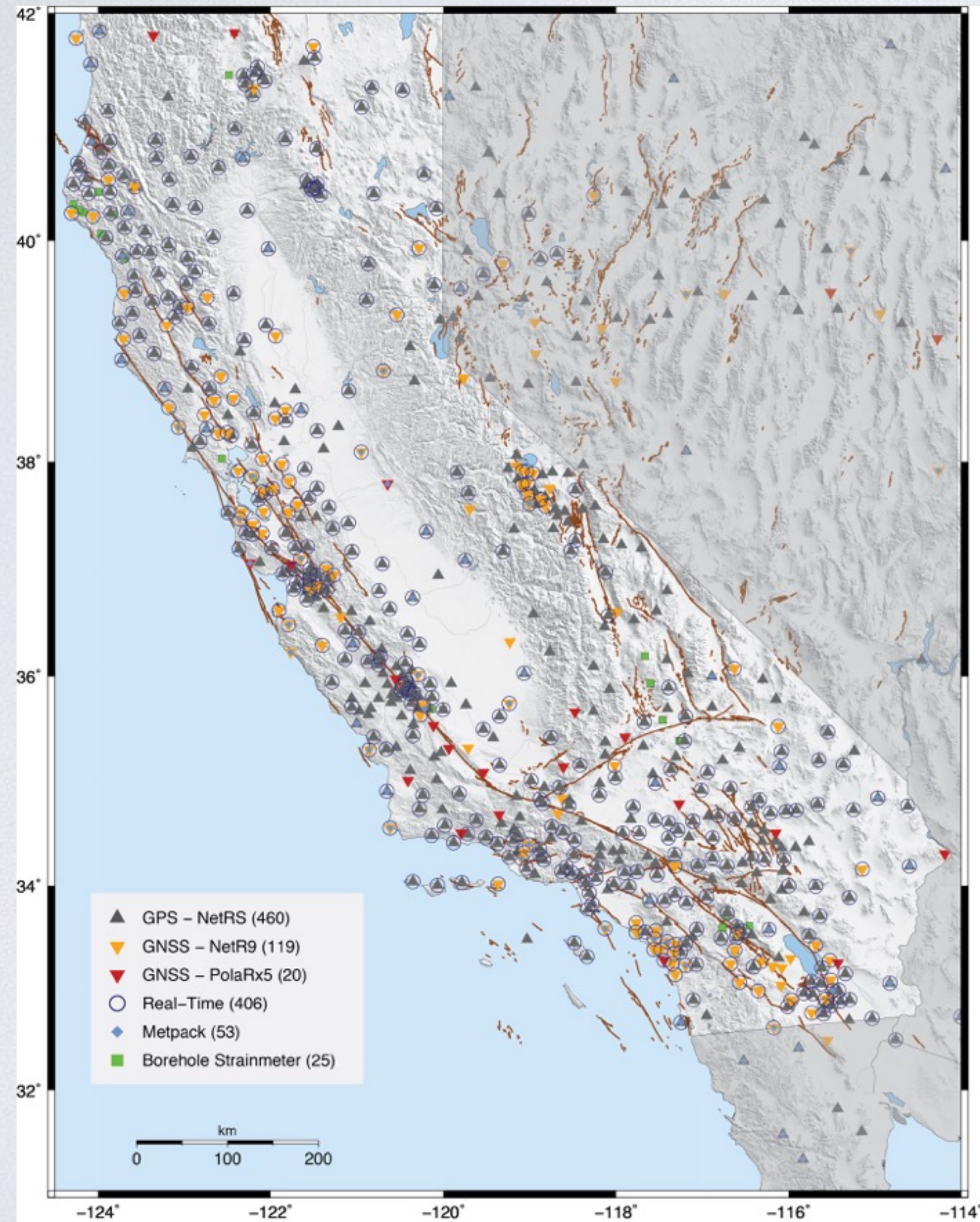


DEVELOPMENT AND TESTING



US Department of Transportation Adjacent Band GNSS Receiver Testing setup inside the anechoic chamber at the Army Research Laboratory, White Sands Missile Range, NM (response to Ligado Inc, formerly known as LightSquared)

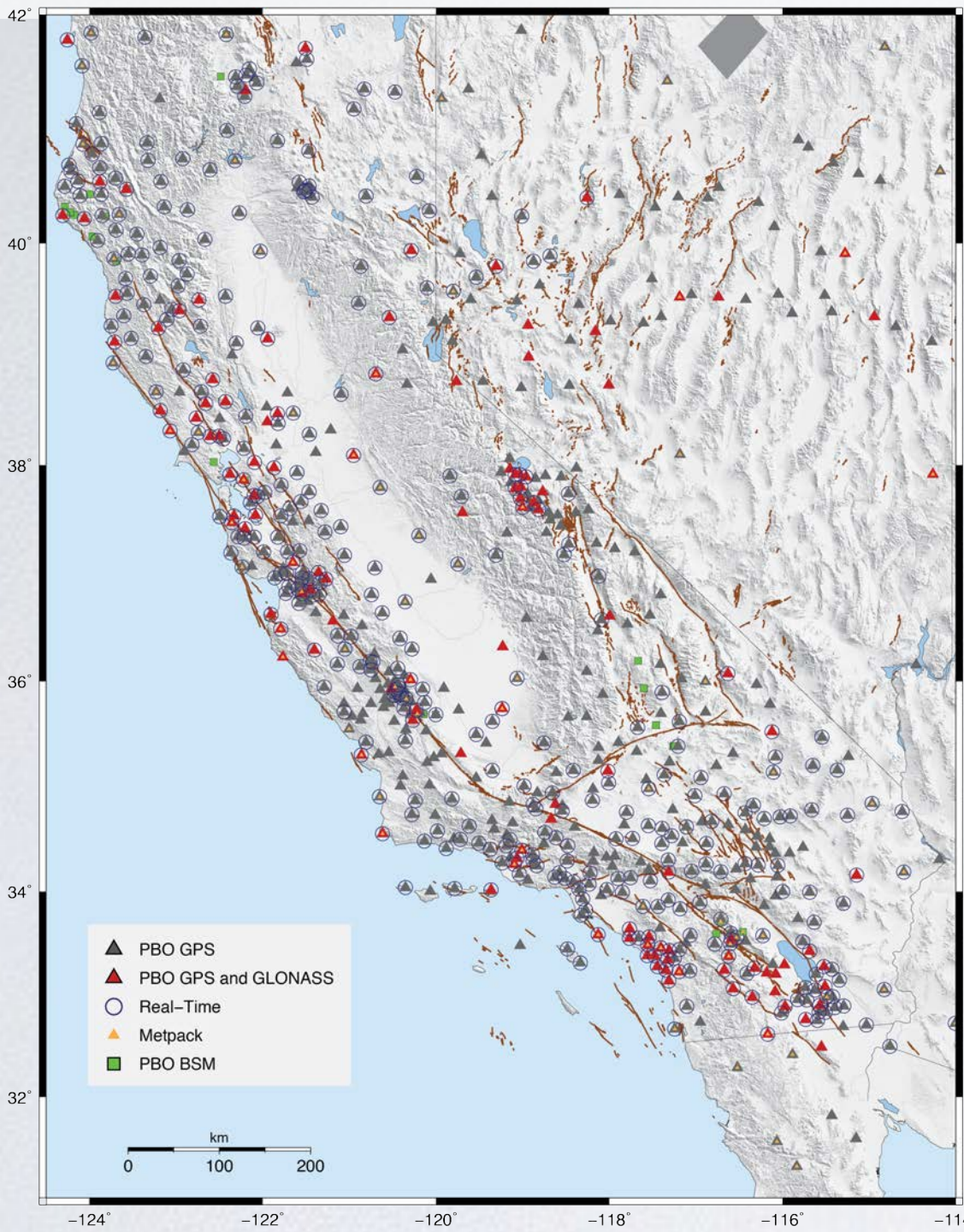
CALIFORNIA PBO NETWORK



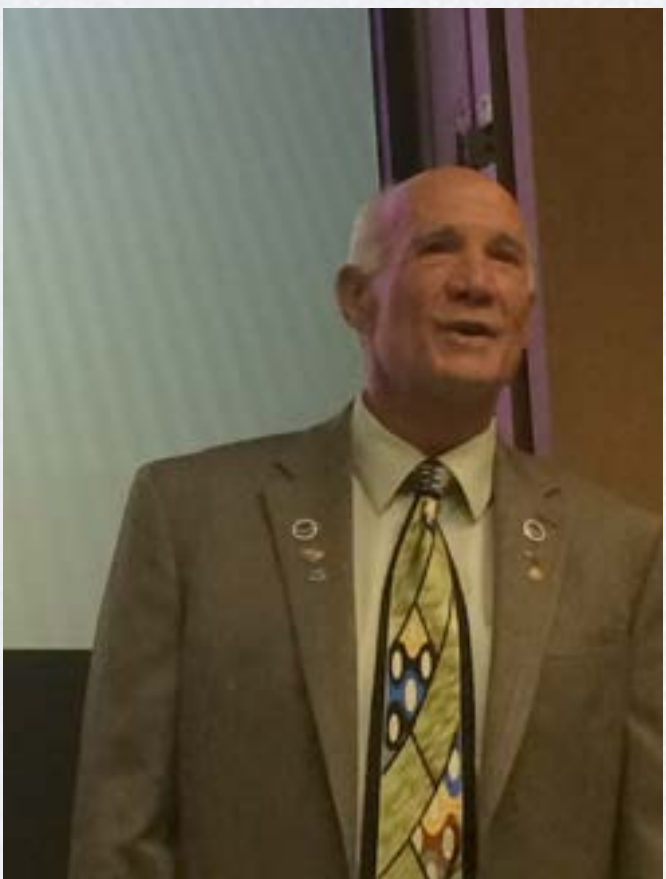
- 599 Stations ~50/50 DDBM/SDBM
- \$27-32M Construction, \$3M/yr Maint/Data
- 458 NetRS (GPS)
- 119 NetR9 (GLONASS)
- 22 PolaRx5 (GNSS)
- 406 Real-Time
- 53 Metpack
- 85%+ 5Hz, 98% 1Hz, 67%+ can stream 1Hz

CA GPS OPERATIONS GROUP

- Last 12m, ~3.75 FTE field engineering staff for 599 stations
- 2.25 FTE on other projects and management
- 160 stations / FTE
- 445 engineer-days in the field, 370+ onsite visits, 800+ issues
- 118 days/year per FTE (~50% of work year in the field)
- 95-100% uptime, >99% data return



Andre Basset
 Shawn Lawrence
 Doerte Mann
 Ryan Turner
 Chris Walls
 Adam Woolace
 Biller Hofferber



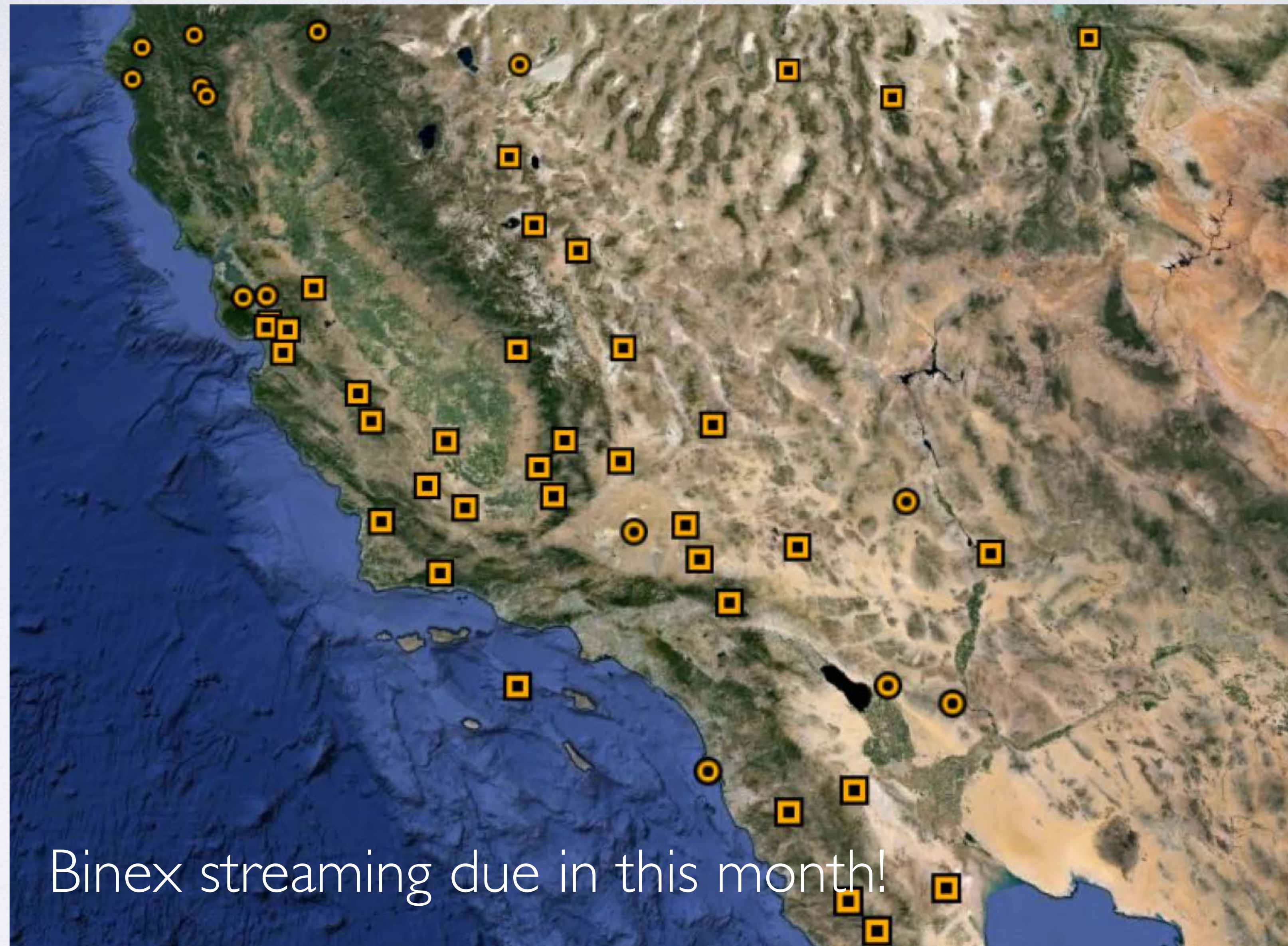


Highlights

- GPS/GNSS Uptime Declining - Decreased Budget since 2012, further cuts in 2017/2018
- All NetR9s activated with GLONASS (most stream) 119 in CA (thank you, Caltrans, for codes and receivers)
- Configured and activated 200 more RT stations in CA (testing in BKG). So 406 in CA.
- Receiver RFP, Review, Testing = Septentrio PolaRx5. Receivers being deployed ~40 planned for CA (Low Power, RFI Mitigation, Multipath Mitigation)
- Planned Continued Receiver and Communication Upgrades for Future Capabilities but at a lower rate in 2017/2018.
- Supported scores of airborne liar surveys all around the state

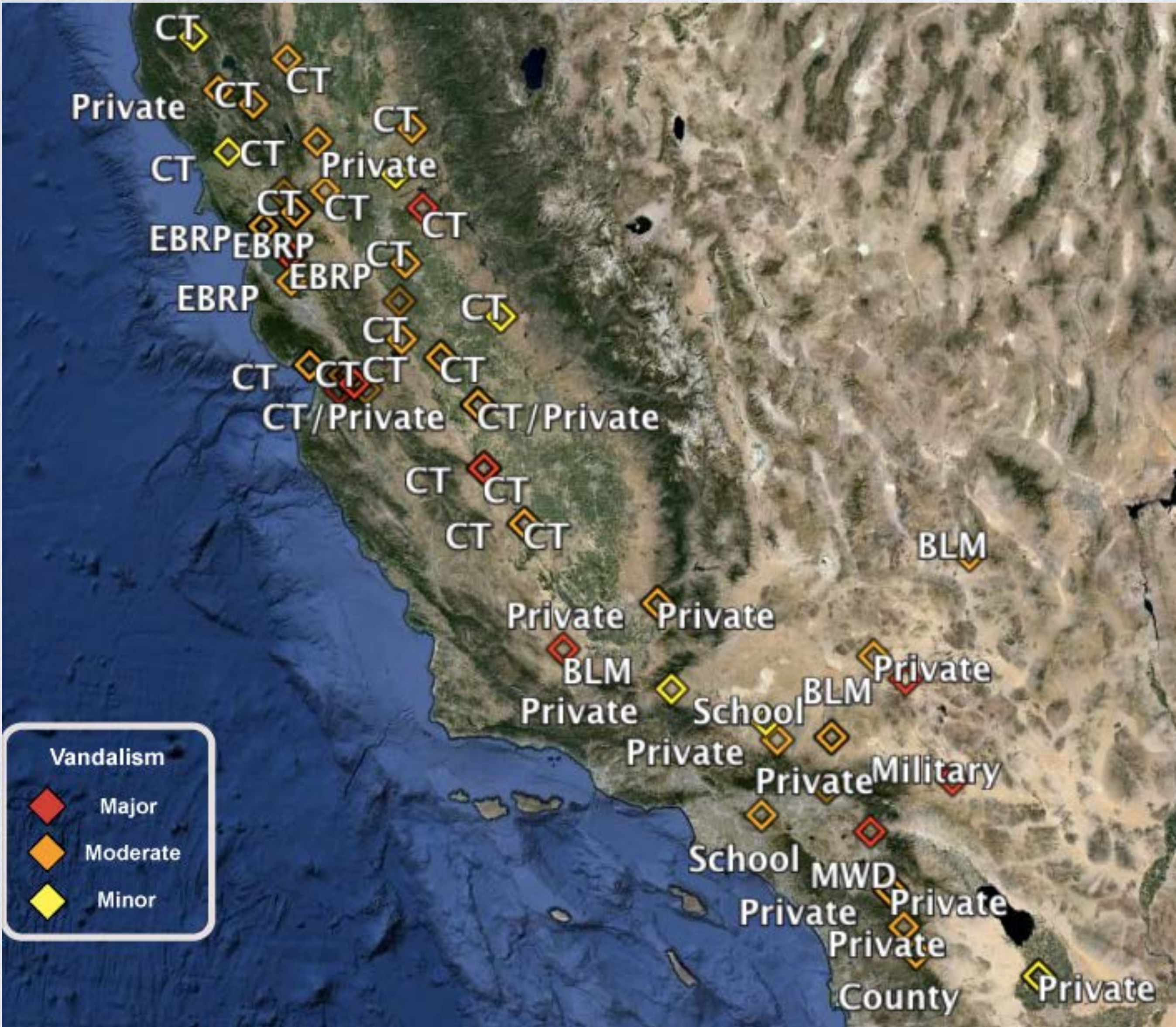


SEPENTRIO UPGRADES HAPPENING NOW



Binex streaming due in this month!

VANDALISM REGION-WIDE - 90+



| Phum | Lat | Long | Name | Date (logged) | Vandalism | Vandalism Notes | Severity | Repeat? | Owner type |
|------|------------|------------|------------------|---------------|---|---|----------|----------|------------|
| DHAB | 37.72412 | -122.11830 | Chabot | 1/8/13 | Antenna twisted off wellmount | Gee was decommissioned | Major | multiple | ESRP |
| DHAB | 37.72412 | -122.11830 | Chabot | 3/2/09 | Dome cracked | | Moderate | multiple | ESRP |
| DHMS | 34.642461 | -117.8277 | Challenger MS | 9/20/10 | local AC box pulled out | | Minor | once | School |
| 40A | | | Instanta 40 | 8/6/13 | removed solar panel strut | improvised repair | Minor | once | Caltrans |
| JNMT | 35.0802023 | -116.93885 | LHMT | 3/12/14 | Solar theft attempt and smashed | armor, panels mounted higher | Moderate | multiple | Private |
| JNMT | 35.0802023 | -116.93885 | Lane Mountain | 4/20/08 | Solar panel wires cut, dome smashed | new dome, repair of wires, eventual Nucleus upgrade | Moderate | multiple | Private |
| P177 | | | | 4/20/13 | 1 solar panel shattered, sign destroyed | | Minor | once | |
| P181 | 37.91454 | -122.37680 | Miller Knox | 1/24/08 | Fence damaged | | Moderate | multiple | ESRP |
| P181 | 37.91454 | -122.37680 | Miller Knox | 1/19/08 | fence, cracked dome, coma antenna | | Moderate | multiple | ESRP |
| P181 | 37.91454 | -122.37680 | Miller Knox | 10/25/06 | Solar Panels smashed | Polycarbonate PV cover 3/8" | Moderate | multiple | ESRP |
| P181 | 37.91454 | -122.37680 | Miller Knox | 5/16/05 | Radome broken, antenna damaged | Polycarbonate PV cover 3/8" | Moderate | multiple | ESRP |
| P190 | 36.241955 | -123.20425 | Ukiah | 1/15/08 | PV theft attempt | | Minor | once | CT |
| P197 | 36.42850 | -122.70740 | Santa Rosa | 5/12/06 | PV theft attempt | PV wires cut and back panel cover removed | Minor | once | CT |
| P203 | 36.66811 | -122.91700 | Mayacmas | 8/22/08 | Choke ring/dome shot | | Moderate | once | Private |
| P206 | 36.77782 | -122.57580 | Crazy Creek | 9/30/06 | PV taken, coma antenna taken, cables cut, enclosure knocked down | Enclosure box removed but left on ground | Moderate | once | CT |
| P208 | 36.10830 | -122.30360 | Salt Canyon | 1/8/07 | PV taken | | Moderate | once | CT |
| P212 | 36.96201 | -121.86272 | Larkin Valley | 1/16/09 | PV taken, bent enclosure post | | Moderate | multiple | CT |
| P212 | 36.96201 | -121.86272 | Larkin Valley | 7/15/06 | Attempt PV, bent enclosure post | Couldn't take PV so hit post with car/bush | Moderate | multiple | CT |
| P222 | 37.53824 | -122.08330 | Coyote Park | 6/16/08 | PV broken | added polycarbonate, security enclosure | Moderate | once | ESRP |
| P236 | 36.90354 | -121.55450 | Loma Linda | 10/5/12 | Enclosure broken into, batteries taken, LCI and NetRS found nearby, take security cameras/armor taken | added real camera, signs, small sign, move cable to semi-internal conduit | Major | multiple | CT |
| P236 | 36.90354 | -121.55450 | Loma Linda | 1/10/14 | PV taken, enclosure post cut, gate removed | | Moderate | multiple | CT |
| P236 | 36.90354 | -121.55450 | Loma Linda | 6/12/06 | PV taken | | Moderate | multiple | CT |
| P238 | 36.648279 | -121.45277 | Flint Hills | 7/23/12 | On 4/11/2012 monument was hit, antenna casting messed with | | Moderate | multiple | CT |
| P238 | 36.648279 | -121.45277 | Flint Hills | 6/11/11 | Receiver, dome, batteries | added (fake) armor, sign, light | Major | multiple | CT |
| P251 | 36.61145 | -121.34790 | Tree Pines Creek | 5/8/06 | PV taken | | Moderate | once | CT |
| P252 | 37.16886 | -121.25770 | Quinto Creek | 6/20/06 | PV taken | | Moderate | once | CT |
| P259 | 37.43302 | -121.10060 | Patterson | 7/3/07 | radome shattered | no damage to antenna | Moderate | once | CT |
| P261 | 36.15290 | -122.21754 | Hummer Hill | 7/17/12 | enclosure damaged, backpanel taken | | Moderate | once | CT |
| P262 | 36.02515 | -122.09610 | Waterbird | 5/28/13 | enclosure door door pried open | equipment not taken, needs enclosure as cutting PV wire brought site down | Moderate | multiple | ESRP |
| P262 | 36.02515 | -122.09610 | Waterbird | 11/13/07 | PV attempt | | Moderate | multiple | ESRP |
| P262 | 36.02515 | -122.09610 | Waterbird | 7/16/07 | PV taken | | Moderate | multiple | ESRP |
| P264 | 36.02515 | -122.09610 | Capell Valley | 4/1/07 | radome broken | Broke lower panel | Moderate | once | CT |
| P265 | 36.53219 | -121.95420 | Putah Creek | 6/21/06 | PV theft attempt, panel broken | | Moderate | once | CT |
| P266 | 36.18397 | -121.84300 | Little Horner | 6/13/06 | PV taken | | Moderate | once | CT |
| P275 | 36.32453 | -121.21460 | Kanelick Ranch | 11/17/05 | dome cable damaged, attempt at theft | Redbull drilled into enclosure, no exposure | Minor | once | Private |
| P276 | 36.64531 | -121.09520 | El Dorado Hills | 12/20/06 | PV taken | | Moderate | once | CT |
| P300 | 36.36443 | -120.27700 | Harris Ranch | 6/1/09 | Wires and CDMA taken | | Major | multiple | CT |
| P303 | 37.05438 | -120.70530 | Los Banos | 10/21/06 | PV smashed | After PV welded on they just shattered th | Moderate | multiple | CT |
| P303 | 37.05438 | -120.70530 | Los Banos | 12/16/06 | PV attempt | After PV welded on they just shattered th | Moderate | multiple | CT |
| P304 | 36.73800 | -120.35660 | Mendota | | Panel smashed and theft | | Moderate | multiple | CT/Private |
| P304 | 36.73800 | -120.35660 | Mendota | 9/23/10 | PV brackets damaged | | Minor | multiple | CT/Private |
| P304 | 36.73800 | -120.35660 | Mendota | 6/15/12 | Enclosure post cut, PV taken | mounted PV on bunker roof | Moderate | multiple | CT/Private |
| P305 | 37.36221 | -120.19680 | Planeta | 2/21/06 | attempt at theft, GPS cable liquite undone | Conduit unscrewed | Minor | once | CT |
| P309 | 36.06999 | -120.95120 | Calaveras | 1/5/06 | Full replacement of equipment | | Major | multiple | CT |
| P309 | 36.06999 | -120.95120 | Calaveras | 6/3/10 | Hacksaw attempts at U-bolt | | Minor | multiple | CT |
| P309 | 36.06999 | -120.95120 | Calaveras | 4/4/13 | Liever pried partially open. Monument leg slightly bent - no timesakes affect. | | Moderate | multiple | CT |
| N479 | 33.492317 | -116.78293 | Cowboy Country | 2/1/13 | Radome shot dome with BGLs | | Moderate | multiple | Private |
| N479 | 33.492317 | -116.78293 | Cowboy Country | 1/15/10 | Lower panel smashed | | Moderate | multiple | Private |
| N479 | 33.492317 | -116.78293 | Cowboy Country | 2/24/06 | attempt at trying to break into enclosure box | Door repaired, 3rd lock installed | Moderate | multiple | Private |
| N482 | 33.242176 | -116.67141 | Lake Mendocino | 1/16/11 | PV taken | Repaired and armor installed | Moderate | once | Private |
| N483 | 33.055103 | -116.56932 | Julian Blin | 4/26/11 | PV smashed and nearly stolen | New security brackets installed - eventually required rewiring of components | Moderate | once | County |
| N488 | 32.89843 | -115.56850 | Speckles | 10/21/06 | PV taken | Later enclosure armor installed | Moderate | multiple | Private |
| N488 | 32.89843 | -115.56850 | Speckles | 10/10/05 | conduit cut, support bracket dismantled, solar panel theft attempt | | Minor | multiple | Private |
| P506 | | | Ramsey Lake | 4/24/13 | Cut antenna cable at monument and enclosure | Retrenched and installed 1/2" square. Resulted in 12 days data loss | Moderate | once | State |
| P522 | 35.0889112 | -119.53806 | Camino | 6/21/09 | Dome/cabling shot | replaced dome | Moderate | multiple | BLM |
| P522 | 35.0889112 | -119.53806 | Camino | 11/22/13 | Choke ring/dome smashed violently; enclosure replaced | enclosure replaced, armor installed | Major | multiple | BLM |
| P522 | 35.0889112 | -119.53806 | Camino | 1/19/04 | Attempt to gain access to enclosure, pry and scratch marks on armor/enclosure | plan to reinforce enclosure armor, and since this is the 3rd instance to enhance security and add cameras | Moderate | multiple | BLM |
| P544 | 35.7312678 | -119.73804 | Twisselmann | 3/8/13 | Solar panels stolen | | Moderate | multiple | CT |
| P547 | 36.014701 | -116.69216 | Ukiah | 1/10/06 | Lightening sponge smashed, solar panels smashed but still producing power | | Moderate | multiple | CT |



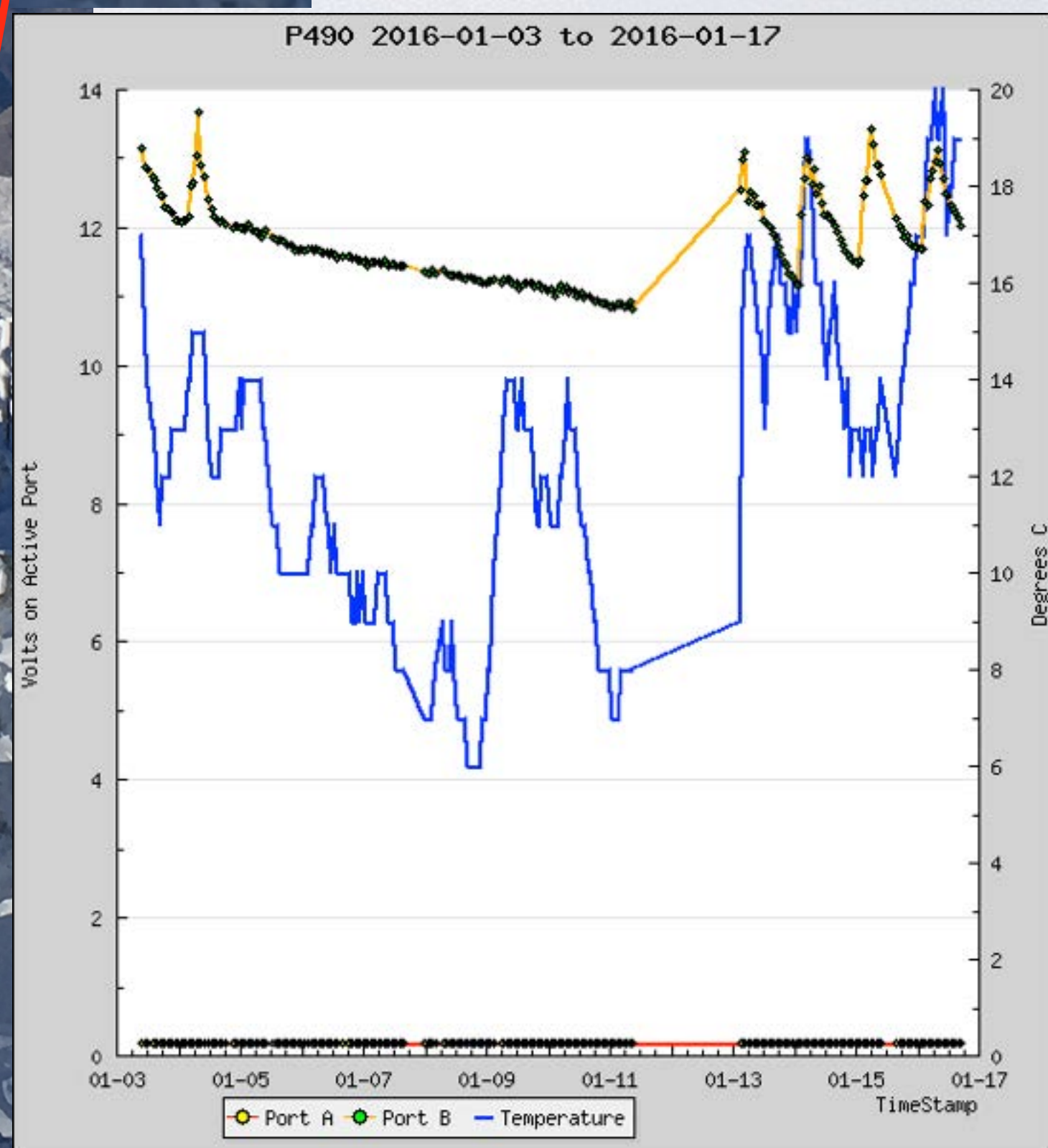
P522 - A HISTORY OF ABUSE...AND ENDURANCE

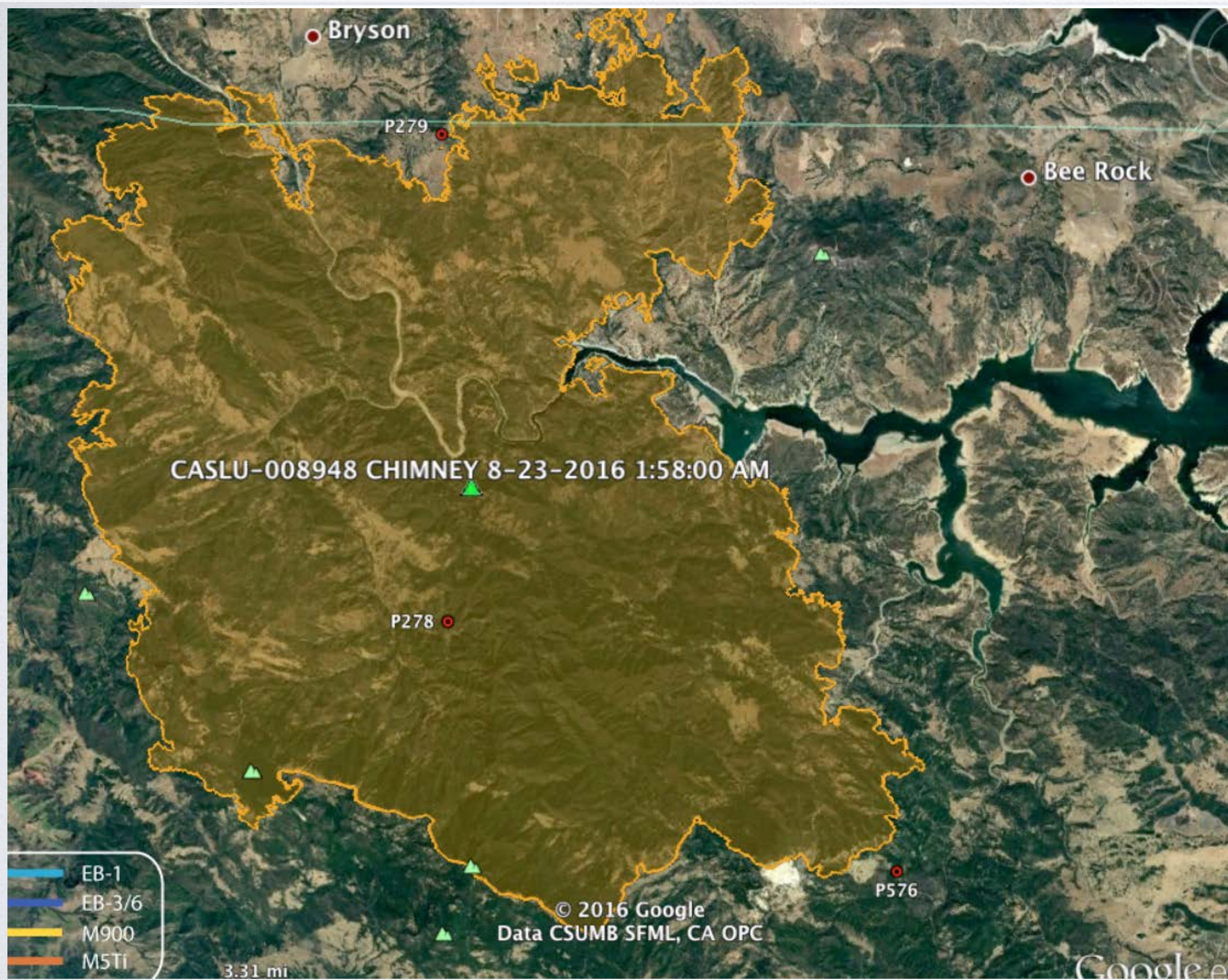


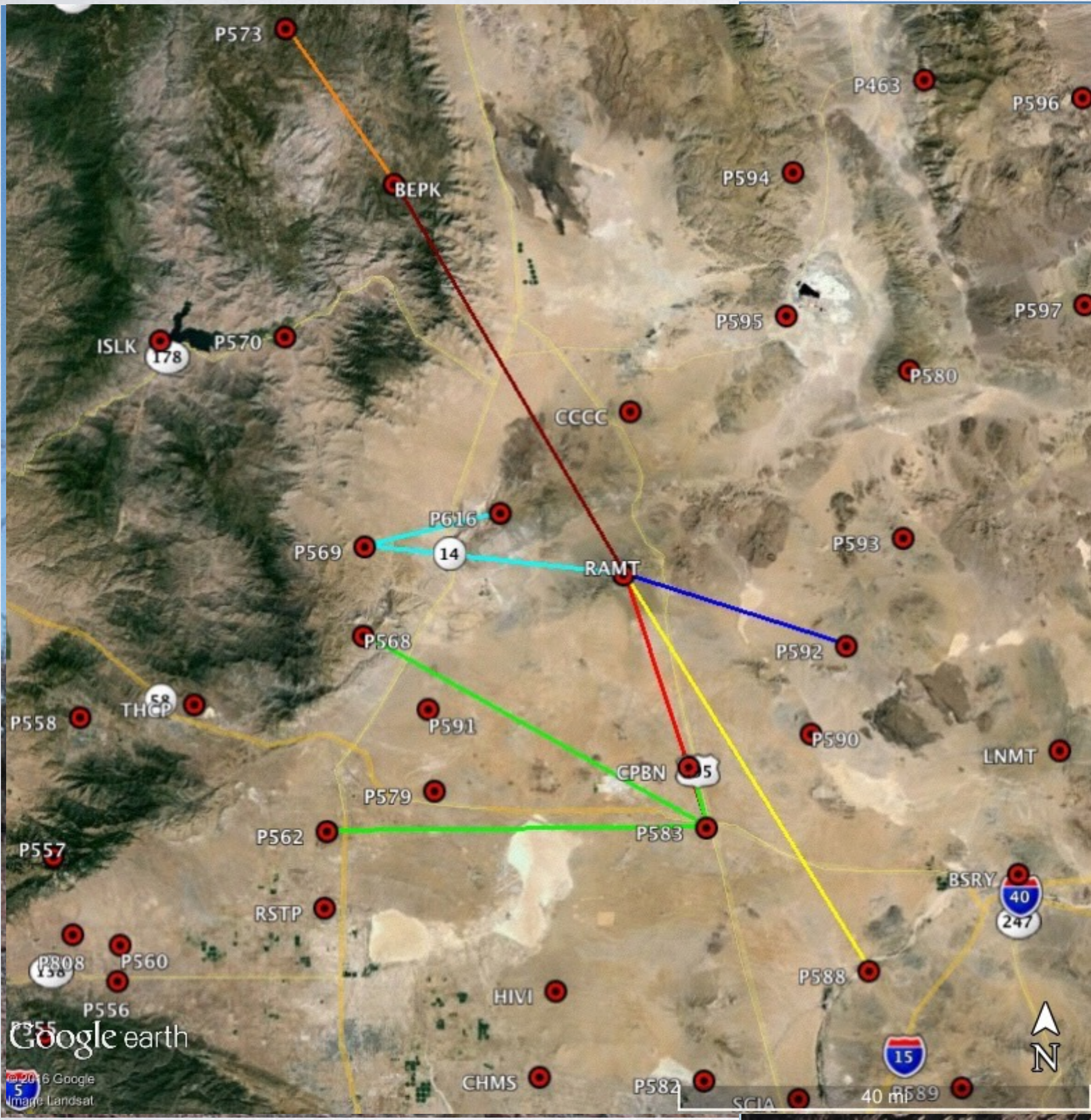
P522 Transformation



SOLAR POWER = AUTONOMY = VULNERABILITY









UPCOMING PROJECTS

- Modest expansion of Geodetic Module sites
- One station in San Diego County
- Menlo Park server upgrade
- Death Valley radio network upgrade
- LOS + radio testing with USGS for EEW
- Proposal for NGENO



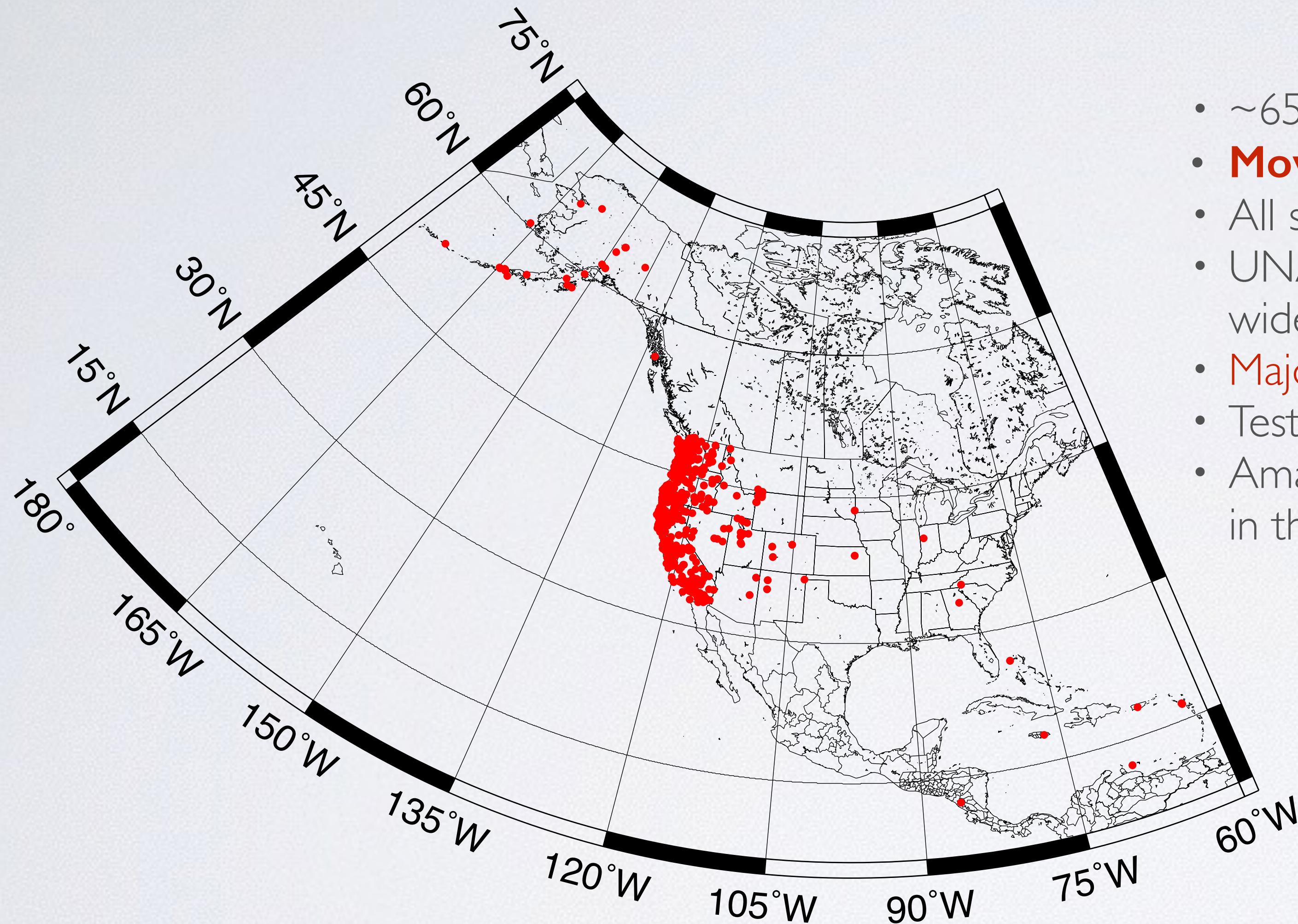
RT-GPS - CURRENT NETWORK

Current Network

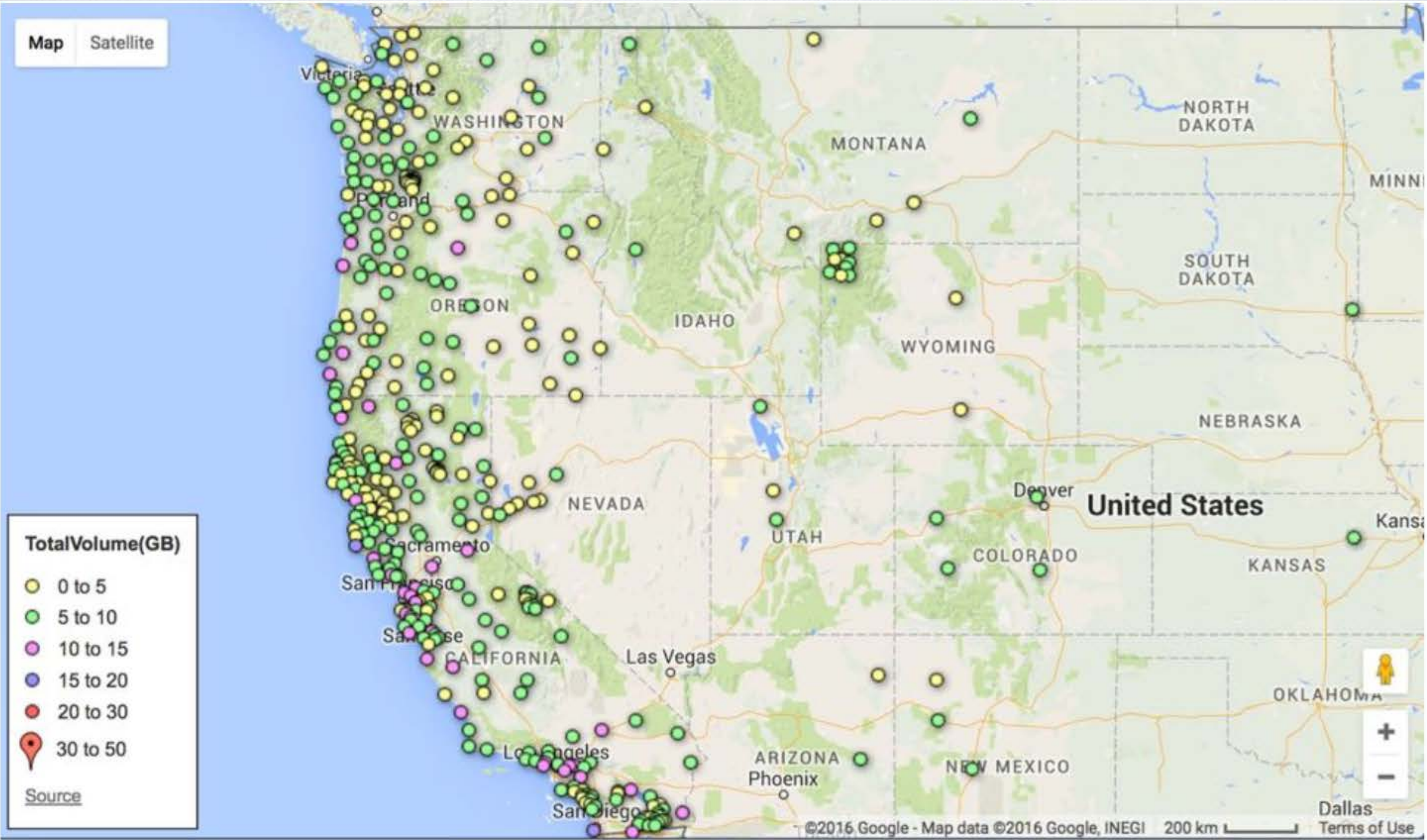
- ~650 Real-time stations
- **Moving towards archiving all data at 1 Hz**
- All sites producing RTX point positions
- UNAVCO also participating in initiative for open Pacific wide data, NASA is leading through the State Department
- **Major upgrade to PIVOT is underway**
- Test of archive quality streams in process (limited to NetR9)
- Amazon grant received to test ~250 sites with all resources in the cloud.

Concerns

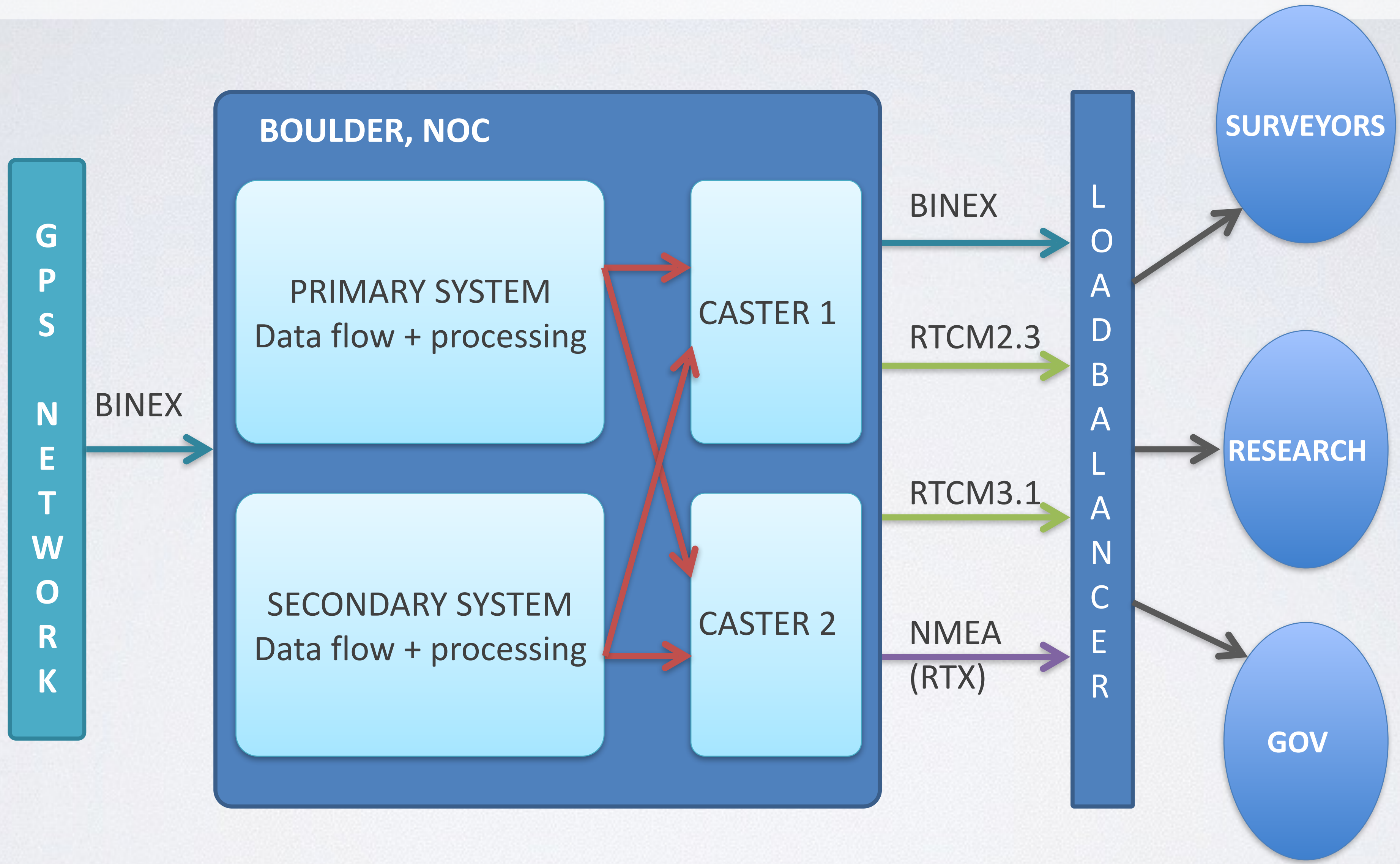
- Network side capacity for > 1 Hz data
- Archiving multiple data sets for same sample rate and station. (How to present this).
- **Very low dedicated resources**
- Ill defined formats for processed real-time positions (UNAVCO will propose an EYRO/BNX hybrid - still need for SEED analog).
- Station Communication Costs!



Q3 CUMULATIVE VOLUME OF RT DOWNLOADS

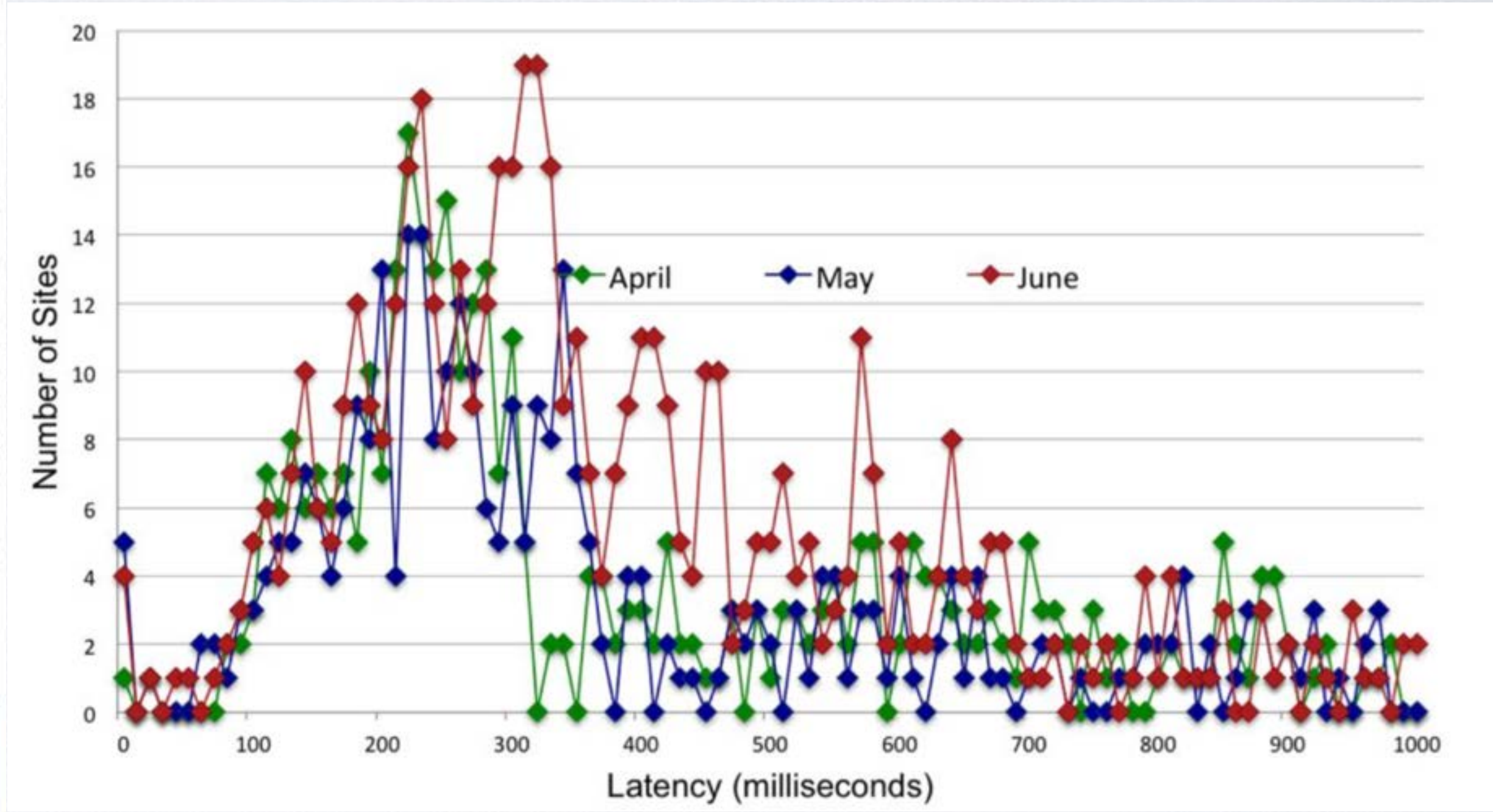
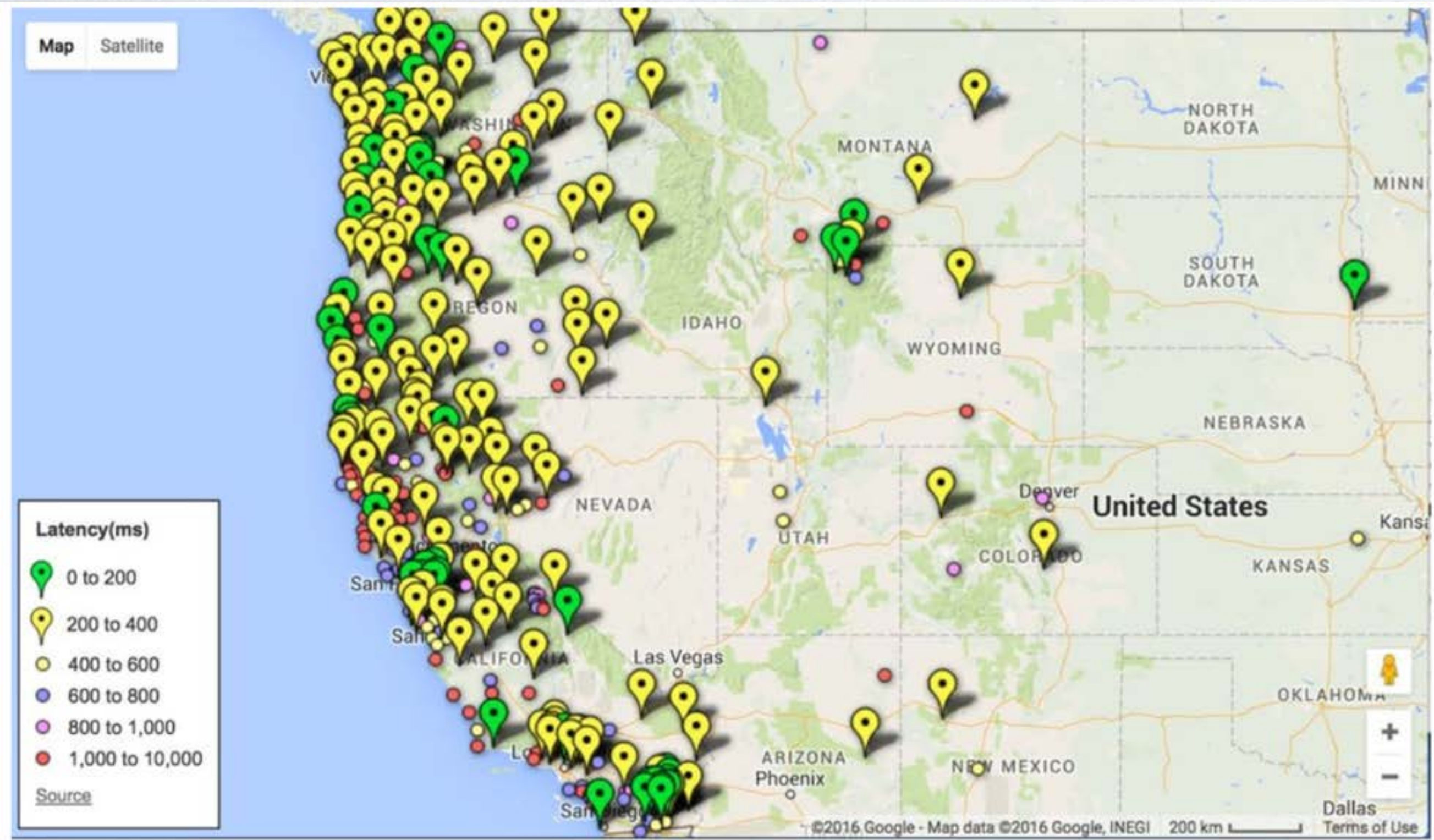


REALTIME GPS DATAFLOW AT UNAVCO

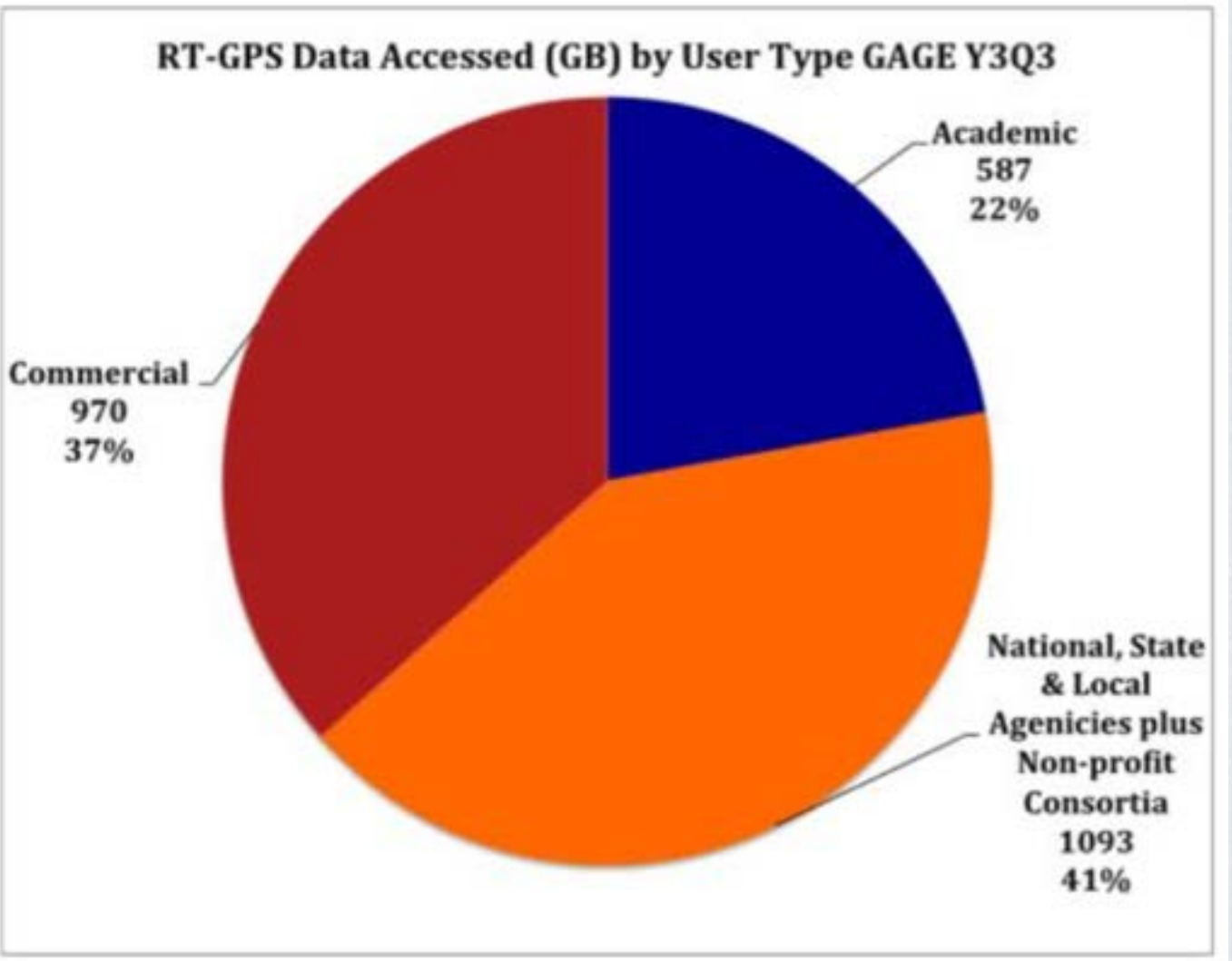
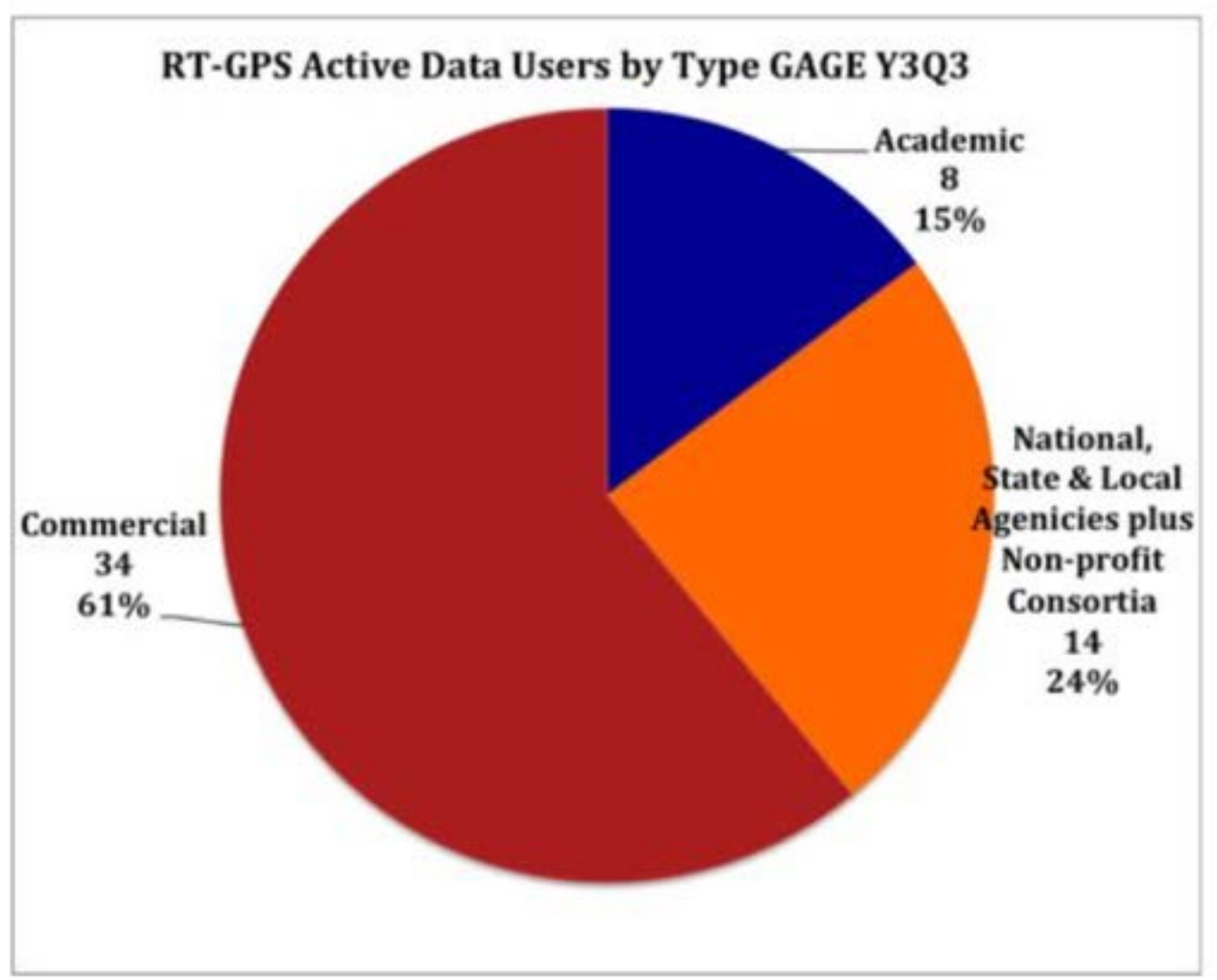
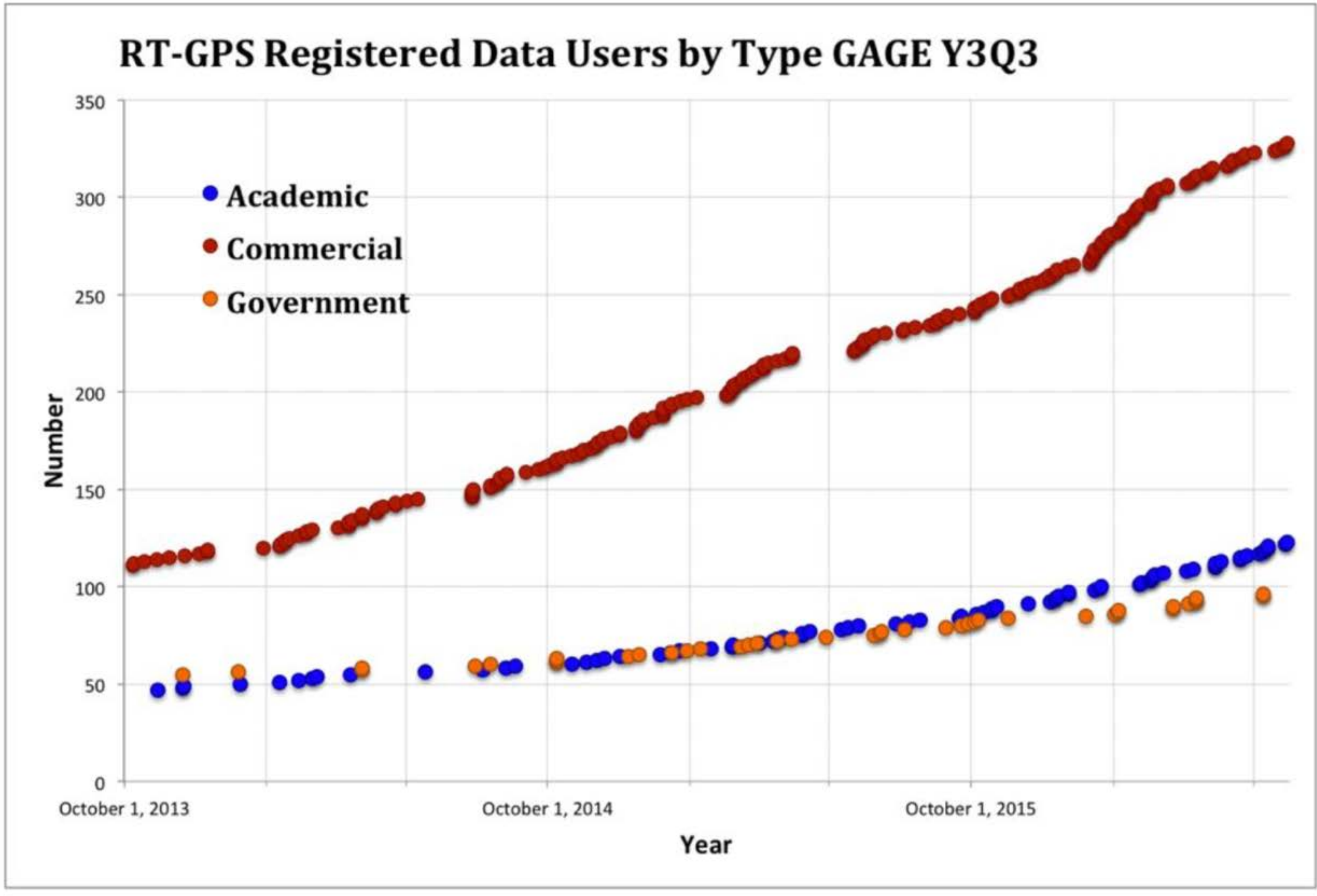


Primary and secondary systems provide redundancy, both run simultaneously

LATENCY

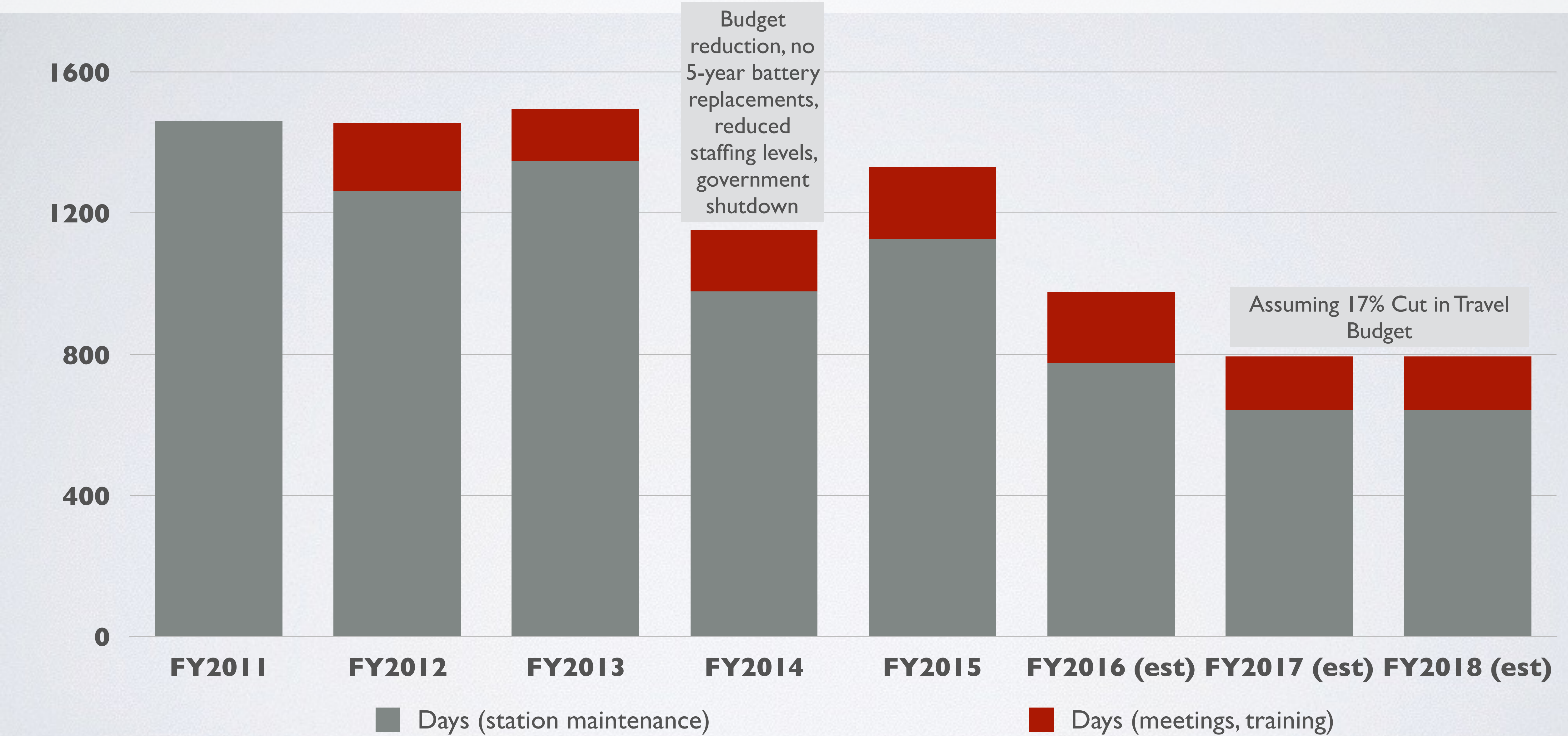


REAL-TIME DATA & USERS



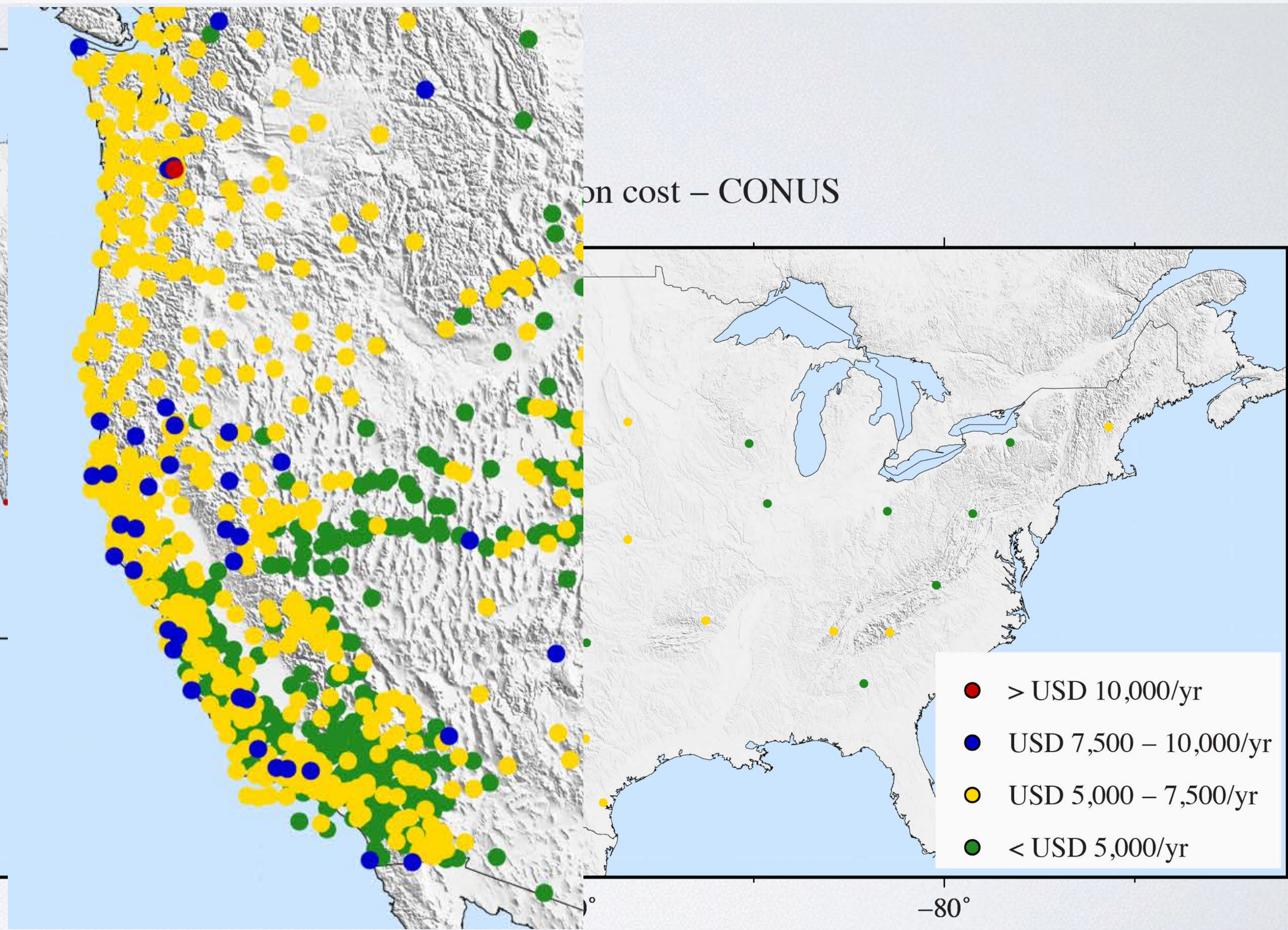
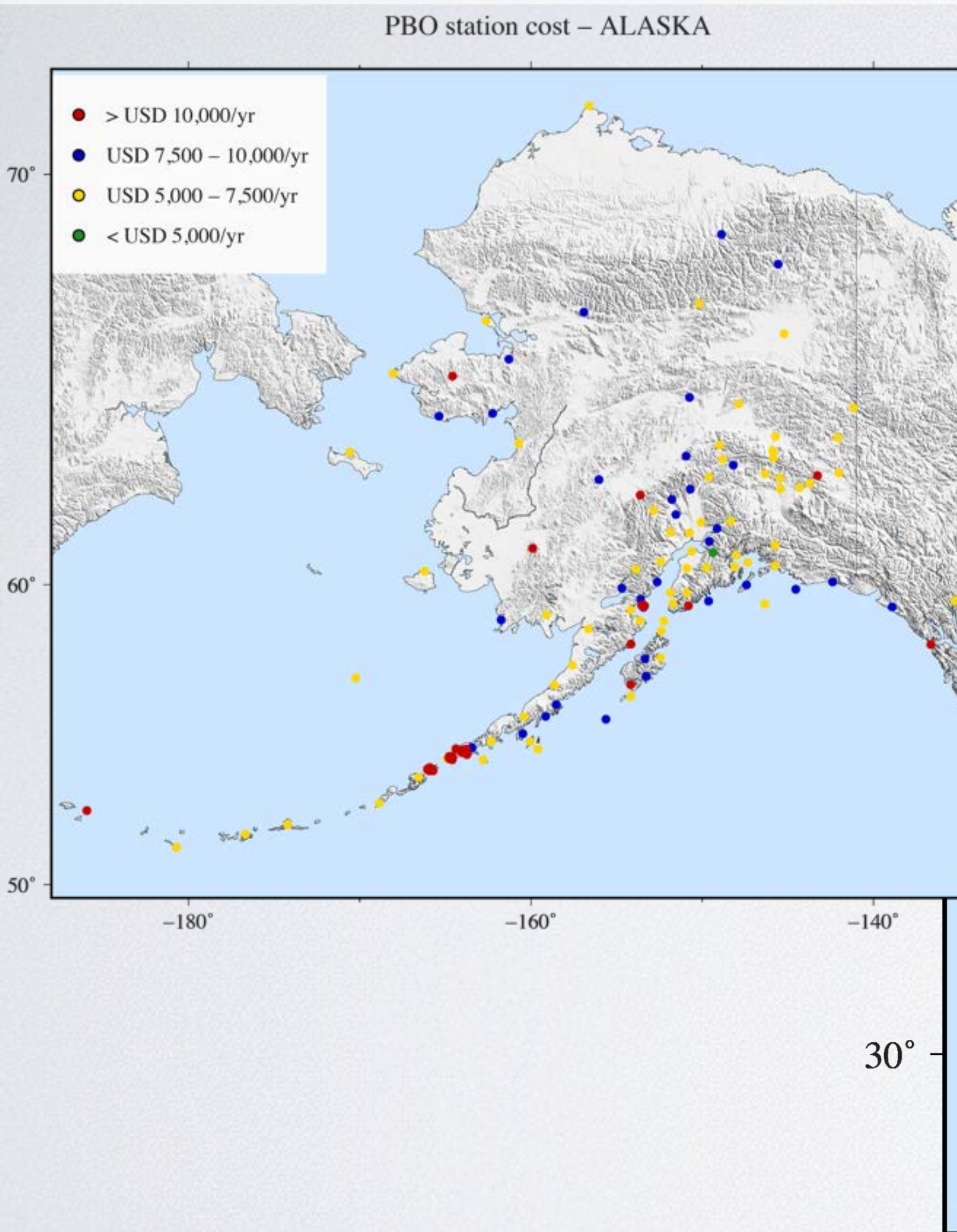


ENGINEER DAYS IN FIELD



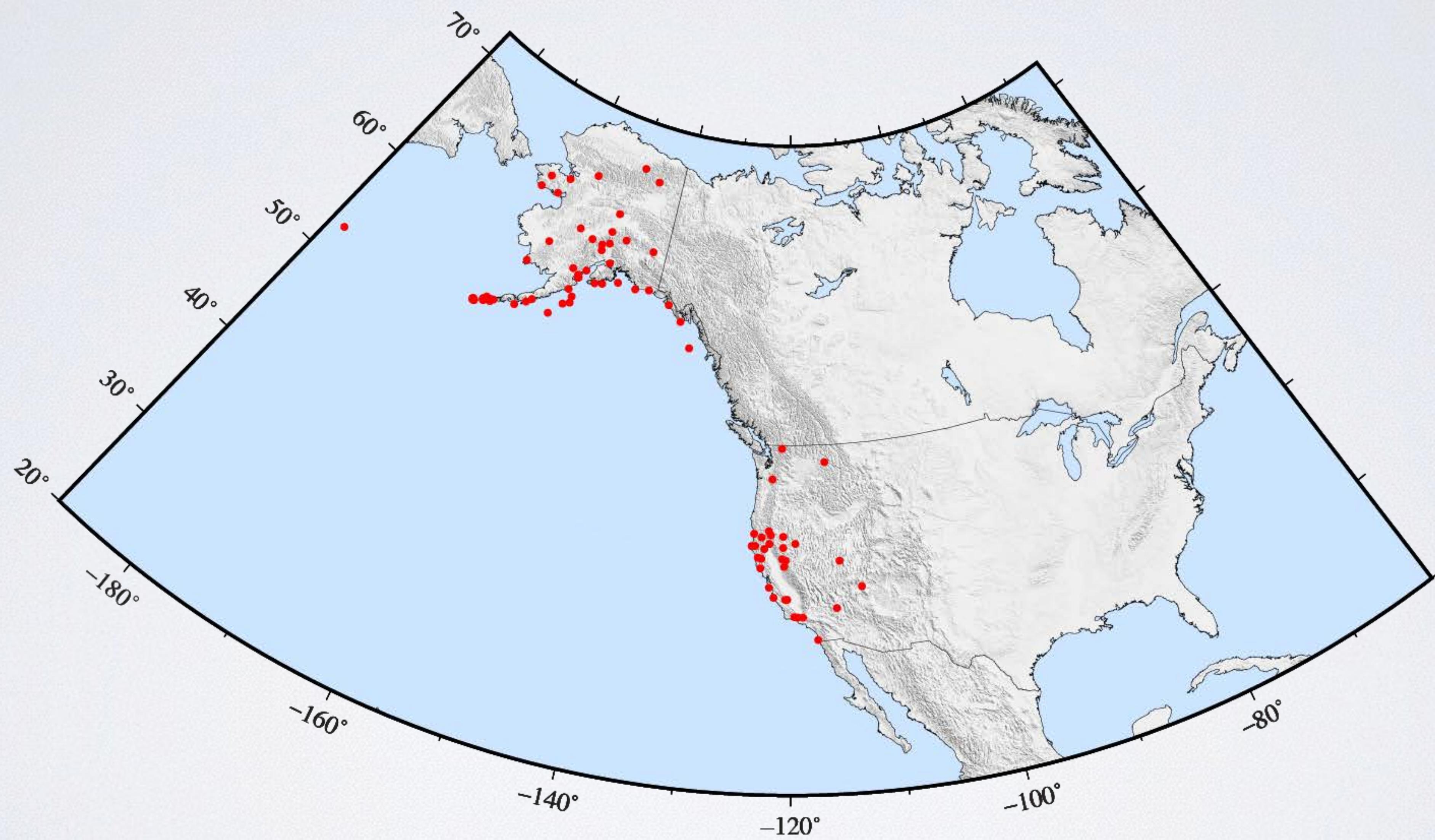


OPERATIONS AND MAINTENANCE COSTS: CONUS AND AK





100 MOST EXPENSIVE STATIONS





NGEO - NATIONAL GEOPHYSICAL OBSERVATORY

- 1-5 Awards, Universities/NonProfits, Support Mission goals of NASA, NOAA, USGS
- Letter of Intent submitted in August. Proposals Due Dec 28, 2016. Duration - 10 yrs
- Foundational - Maintain capabilities that are fundamental and essential to present and near-term science directions, including the continuation of currently funded NSF projects (NOTA, BSM, TLS, Seismic)
- Emergent Foundational - Components that incorporate current technologies would drive significant progress on major science challenges and were judged to be high priority for the 2018–2023 time frame. (GNSS processing, Multi-disciplinary environmental observatories)
- Frontier - Those capabilities that are, to varying degree, nascent, but are of significant interest to the community for their potential to enable transformative science and ensure continued scientific progress. (high risk/benefit experiments, seafloor/float seismic and geodetic networks)

- NGE0 - What level of funding could be hoped for? Less than now and certainly less than needed to a) upgrade the network and b) ensure RT at high level
- What stations would be cut? None immediately. Thereafter, prioritize, or perhaps let clusters of stations go such as helicopter access-only volcanic sites. We are trying to keep the network whole
- Is there an Adopt-A-Station plan? No, Not yet
- Do you need partners? Yes, the need for significant sustaining partners remains paramount



END

