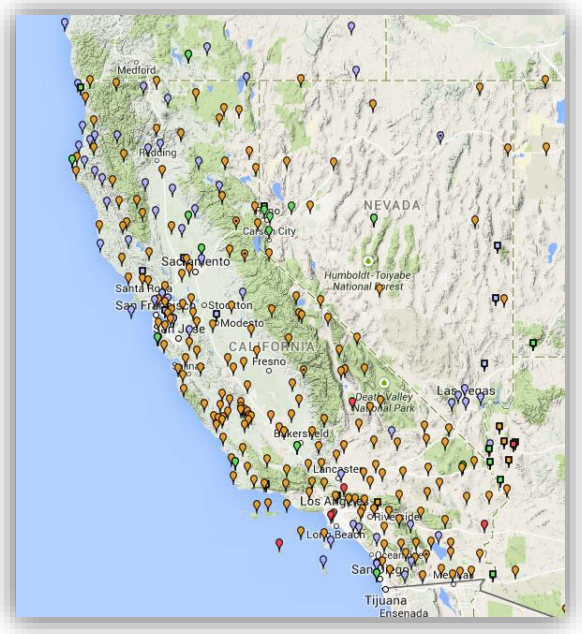
GEODETIC CONTROL THEME

CURRENT GRADE: B+
POTENTIAL GRADE: D or F



NGS CORS stations in California

Discussion: On February 6, 2015 the Coalition of Geospatial Organizations (COGO) released its report titled "*REPORT CARD ON THE U.S. NATIONAL SPATIAL DATA INFRASTRUCTURE*", which included the Geodetic Data Theme (GDT). Of the seven themes evaluated and graded in the COGO report, the GDT received the highest grade of a B+. The next highest grade was a C+ for Elevation Data and Orthoimagery Data. This high grade was awarded primarily due to the efforts of the National Geodetic Survey (NGS) to provide robust access to the National Spatial Reference System (NSRS) through the network of Global Positioning System (GPS), Continuously Operating Reference Stations (CORS), known as National CORS. Additional high value was given language contained in the NGS "*Ten Year Strategic Plan 2013-2023*".

Specifically, Goal 3 of that plan, as paraphrased in the COGO report states:

"Expand the National Spatial Reference System (NSRS) Stakeholder Base through Partnerships, Education, and Outreach."

With approximately 253 active NGS CORS stations in California, it is reasonable to apply the same evaluation criteria to the California Geodetic Control theme, thus yielding a current similar grade of B+ or better.

However, more than 98% of all NGS CORS stations, approximately 2,500 total, are not funded, owned, or operated by NGS, but by other entities that make the data from the CORS stations available to NGS to provide access to the NSRS. This relationship was only briefly mentioned in the COGO report in this paragraph:

The CORS network is a near-perfect example of the recent success in national collaboration. The network is operated by over 200 organizations, with the data managed and maintained centrally by NGS. It is utilized by thousands of unique users every month.

What is not discussed in the COGO report is the long-term vulnerability and risk such a partnership model presents, especially in California.

A. Background in California

As satellite based, high precision position capabilities were developed and implemented through GPS technology in the 1980's, then progressing rapidly in the 1990's, NGS promoted the development of high precision geodetic control networks in all States to support the use of GPS. These networks are referred to as High Accuracy Reference Networks (HARN) or High Precision Geodetic Networks (HPGN).

In 1991, the original HPGN in California was designed, installed, observed, and implemented through a joint effort between NGS and Caltrans (lead State agency) with contributions from many local stakeholders. The

HPGN was comprised of traditional survey monuments of high stability, with clear views of sky for GPS occupations.

The concept of CORS stations began to emerge a few years after the establishment of the HPGN. Some of the early CORS stations in California date back to the mid 1990's.

Because of the geophysical properties and challenges existing in California in the form of secular tectonic plate drift along fault zones, earthquakes, subsidence, and even volcanoes; geodetic control positions are unstable over time and require periodic updating to remain accurate, in an absolute sense, to the NSRS. Given these unique challenges, and the lack of NGS resources available to properly and adequately address them, the California Spatial Reference Center, Scripps Institute of Oceanography, University of California San Diego (UCSD), was created in 1998 through support and funding from the NGS. The CSRC has the sole codified authority, through the California Public Resources Code, to compute and publish coordinates for the California Spatial Reference System (CSRS). However, due to diminished funding, the CSRC has not been able to keep the CSRS consistently aligned with the NSRS for the past several years.

In 2002, a CSRC committee was formed to develop a CSRC Master Plan. In March of 2003, the CSRC document *"A MASTER PLAN for a MODERN CALIFORNIA GEODETIC CONTROL NETWORK"* was approved by NGS. This document can be accessed in entirety here:

http://csrc.ucsd.edu/docs/csrcMasterPlan.pdf

It is stated in this document that the CSRC's ultimate goal was to establish a California geodetic control network consisting entirely of CORS stations, rather than the type of monuments used for the HPGN, which are referred to as passive survey marks. The proposal was for an evenly spaced (80 km), grid like network covering California, with increased density in more urban areas. The estimated total number of stations to fulfill that need was 275.

Although not entirely as a result of CSRC efforts and resources, a very dense and robust population of roughly 830 Continuous GPS stations (CGPS) has been developed in California in the 12 or so years since the Master Plan was written. This was mostly to support geophysical scientific research. Of the 830 CGPS, 253 are currently incorporated into the NGS CORS network, approximating the original CSRC estimate of 275 installed CORS. As a result, the density and distribution of CORS stations in California is very high when compared to many U.S. states and lower than several others.

The current network provides excellent access to the NSRS in California, so a B+ grade is warranted at this time. However, without dedicated state and local funding to own, operate, or maintain California CORS stations, long-term sustainability of this grade is at high risk.

B. Theme Definition and Relationships

The *"California Geospatial Framework Draft Data Plan"* prepared by Michael Baker Jr., Inc. for the California Geographic Information Association, dated September 2006 stated the following regarding theme description and the relationship to other themes:

"Geodetic control provides a common reference system for establishing coordinates for all geographic data."

"The Geodetic Control theme is used in conjunction with Ortho Imagery to improve the accuracy of many data themes."

C. Lead Agencies

The NGS is the responsible agency for this framework data layer of the National Spatial Data Infrastructure (NSDI) by virtue of maintaining and providing access to

the NSRS. No lead agency for California has been identified. For now, the CSRC remains responsible for determining and publishing positions for the approximately 830 CGPS stations included in the CSRS (including the 253 CORS) while receiving no funding from the State to perform this codified function.

No NGS CORS stations in California are currently owned or funded by the State of California.

The owners of California CORS stations are:

Plate Boundary Observatory (PBO) - 207
Berkeley Seismology Laboratory – 11
US Coast Guard - 8
Scripps Orbital & Permanent Array Center (SOPAC) – 7
US Geological Survey (USGS) – 7
Private vendors, Leica and Trimble – 5
NASA Jet Propulsion Laboratory – 3
Federal Aviation Administration – 2
NGS – 1
City of Modesto – 1
ESRI – 1

Examples of State owned CORS stations elsewhere:

Texas DOT – 153
Michigan DOT – 92
North Carolina Geodetic Survey – 75
Missouri DOT – 67
Minnesota DOT – 58
Ohio DOT – 45
New York DOT – 40
Tennessee DOT – 39
Alabama DOT – 39
Indiana DOT - 36
Iowa DOT – 24

D. Collaboration and Partnering

The CSRC partners with eight other entities that own stations to provide robust, single-baseline, real time network (RTN) access to a subset of the CSRS through the California Real Time Network (CRTN). These partners are; USGS, PBO, SOPAC, Metropolitan Water District of Southern California, Orange County, San Diego County, UC Berkeley, and Caltrans.

CRTN is comprised of 376 stations of which 138 are NGS CORS. A single user account to CRTN is free upon request. Additional accounts are available on a fee basis.

The CRTN White Paper Proposal, dated October 16, 2008 can be accessed here:

http://csrc.ucsd.edu/docs/CRTNProposal_version5.0.pdf

The CRTN Business Plan, dated July 30, 2009 can be accessed here:

http://sopac.ucsd.edu/docs/CRTN_BusinessPlan_09July.pdf

Similarly, the CRSC provides free access to CSRS station data files for user post-processing purposes.

The primary partner of the CSRC providing stations included in the CSRS is PBO, owning approximately 74% of the 830 total stations. The PBO investment in this infrastructure in California is over $30 million to date. Other partners include; USGS, PBO, SOPAC, NASA Jet Propulsion Laboratory, Metropolitan Water District of Southern California, Orange County, San Diego County, UC Berkeley, and Caltrans. Caltrans, as the only State Agency on the list of partners, contributes 21 stations to the CSRS.

E. Standards

The standards for this Fundamental theme are the same as defined in the COGO report, all produced by the Federal Geographic Data Committee.

F. Estimation of completeness

With 253 currently active stations, the CORS component of the NSRS in California provides excellent access to

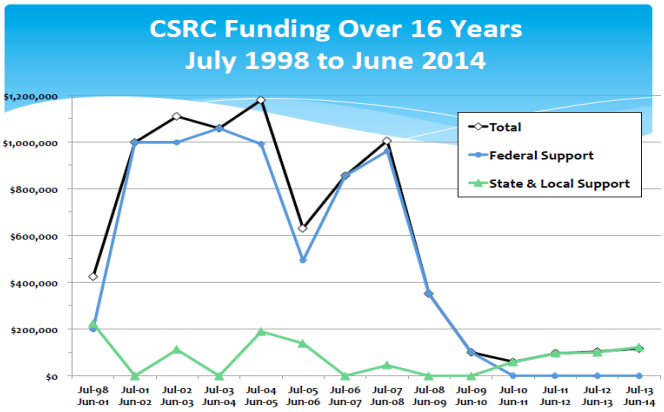
the NSRS statewide for end-user post processing of CORS data. This data is used to determine high accuracy horizontal and vertical geodetic survey control for positioning cadastral data and orthoimagery. CORS solutions also improve the accuracy of many other data themes. NGS also provides the free tool, Online Positioning User Service (OPUS), to compute static point positions relative to the CORS network.

G. Accessibility

NGS Products and services are available from the National Oceanic and Atmospheric Administration (NOAA) website at http://www.ngs.noaa.gov/. Access to the CSRC and CRTN are available at http://csrc.ucsd.edu/ or http://sopac.ucsd.edu/index.shtml.

H. Issues with sustainability of California CORS

Although the CSRC still exists, it no longer receives funding from the NGS, or large state partners. Therefore the primary source of CSRC income is through "pay for access" subscriptions to the California Real Time Network (CRTN) operated by the CSRC. Annual funding for CSRC peaked at about $1.2 million in 2004-05, but is now less than $100,000/year through the CRTN revenue stream.



Of the minimal CSRC funding remaining, none is used to maintain any California CORS stations.

The Scripps Orbital and Permanent Array Center (SOPAC), also located at UCSD, owns seven California CORS, funded by SOPAC, not the CSRC. Currently, the NGS owns only one CORS station in California. This means that more than 99% of California CORS are funded, operated, and maintained by various other partners, including the US Geological Survey (USGS), US Coast Guard, academic institutions, scientific research based organizations, private vendors, and even local governments.

This model is very different than CORS networks established in many other states, such as Texas, Michigan, and North Carolina, where almost all of the NGS CORS stations are funded, owned, operated, and maintained by the state, typically the Department of Transportation. These State agencies have complete control of this very critical positioning infrastructure, ensuring the long term sustainability and availability to end users internally and externally.

Of the 253 currently operational CORS stations in California, 207 (82%) are owned and funded by the National Science Foundation (NSF) and operated and maintained by the Plate Boundary Observatory (PBO), in support of the NSF project, EarthScope. The 15 year EarthScope project began in 2003 and is operated by UNAVCO, Inc. As part of EarthScope, PBO installed various types of instrumentation to monitor and measure tectonic plate movement, detect and characterize volcanic activity, and record seismic events.

Approximately 1,100 CGPS stations were constructed as part of this instrumentation array, approximately 615 (74%) of which are in California and solely PBO funded. This puts a substantial majority of the California geodetic control infrastructure in one PBO supported basket. Herein lies a major concern with sustainability.

On September 30, 2018 the NSF funding for the EarthScope project will end. This means that 82% of the California CORS stations will be unfunded beyond that date if no replacement resources are identified and

implemented. Efforts to find solutions began in early 2014 and have ramped up steadily since, led by outreach from UNAVCO Directors. NGS is unable to fund these stations and would at most maintain about 5 foundational CORS stations in California. The USGS uses much of the data obtained from PBO instrumentation for scientific purposes, but they also lack funding to take over the PBO stations. Any science based entities that might step up to maintain stations beyond 2018 would select specific stations based on scientific value, not spacing and location to support geodetic control. In many remote areas of California, the only existing CORS/CGPS station(s) available to provide coverage and access to the NSRS or CSRS are PBO owned stations.

I. Conclusion

Without a minimum of State and/or local funding, or a completely State owned and operated CORS geodetic control network in California, as has been successfully implemented in many U.S. States; a crisis situation is near. In this senario, accessibility to a current and common reference frame through the NSRS or the CSRS will remain almost completely reliant on various and undeclared outside sources. This model is risky and uncertain, especially considering that PBO has already begun plans to decommission some stations beginning in 2015 with the end of the EarthScope project and all funding in September, 2018.

This is an unacceptable situation that needs to be addressed and corrected at the State level to ensure long term geodetic control access in the support of the California Spatial Data Infrastructure.

If the State fails to develop and implement a plan to provide long term sustainability, the grade for this fundamental theme will certainly fall from the current B+, to a low D or a complete fail almost instantly.

APPENDIX A
REFERENCES and INFORMATIONAL SOURCES

Bossler, Dr. John D., Dr. David J. Cowen, James E. Geringer, Susan Carson Lambert, John J. Moeller, Thomas D. Rust, Robert T. Welch. Report Card on the U.S. National Spatial Data Infrastructure – Compiled for the Coalition of Geospatial Organizations. February 6, 2015.
http://www.cogo.pro/uploads/COGO-Report_Card_on_NSDI.pdf

CORS station information was compiled from the National Geodetic Survey CORS website:
http://www.ngs.noaa.gov/CORS/

NGS Ten Year Strategic Plan 2013-2023 available here:
http://www.ngs.noaa.gov/web/news/Ten_Year_Plan_2013-2023.pdf

UNAVCO/PBO information accessed at:
http://pbo.unavco.org/

The *"California Geospatial Framework Draft Data Plan"* prepared by Michael Baker Jr., Inc. for the California Geographic Information Association, dated September 2006 available here:
http://cgia.org/wp-content/uploads/2011/10/CA_GeoFrame_DDP_FINAL_for_Publication.pdf

The California Public Resources Code Sections 8801-8819, pertaining to geodetic control, can be accessed here:
http://www.leginfo.ca.gov/cgi-bin/displaycode?section=prc&group=08001-09000&file=8801-8819

National Spatial Reference System information here:
http://geodesy.noaa.gov/INFO/OnePagers/NSRSOnePager.pdf
http://celebrating200years.noaa.gov/foundations/spatial/welcome.html
http://geodesy.noaa.gov/INFO/WhatWeDo.shtml

More CORS information here:
http://www.ngs.noaa.gov/INFO/OnePagers/CORSOnePager.pdf
http://geodesy.noaa.gov/INFO/OnePagers/FoundationCORSOnePager.pdf

General information on high accuracy Global Positioning System (GPS) and Global Navigation Satellite System (GNSS) technology:
http://igscb.jpl.nasa.gov/faqs.html#id2839478
http://www.ngs.noaa.gov/PUBS_LIB/pub_GPS.shtml
http://en.wikipedia.org/wiki/Global_Positioning_System