

California Spatial Reference Center
Statement of Work
A plan to implement the National Height Modernization Program in California
FY2002

The Joint Institute of Marine Observations (JIMO) is requesting funding to continue to the support the partnership between the National Ocean Service's National Geodetic Survey and the Scripps Institution of Oceanography's California Spatial Reference Center (CSRC) for the purpose of researching and implementing the National Height Modernization Program in California. This partnership between SIO and NGS is for the mutual benefit of both organizations and the American taxpayer.

We propose to work on the tasks outlined below in the year ahead. This research and development work in California will provide a template, including procedures and guidelines, that can be used for other states in partnership with NGS.

1. CSRC Data Portal

This task is a continuation from FY2001 and will benefit from the expert advice of two Professional Land Surveyors recently hired by the Center (Cecilia Whitaker in southern California and Jim Swanson in northern California). Building upon the database and web interface of the newest version (1.3) of the Site Information Manager (SIM) at SOPAC (http://sopac.ucsd.edu/scripts/SIMpl_launch.cgi), the CSRC will expand this system's capabilities to become a comprehensive online data portal for CORS coordinates and metadata. In support of Height Modernization, each site will include a definitive geodetic reference mark and measurements to recover the station height relative to the current antenna reference point (ARP) should the equipment be changed or removed at some date. The latest processed and approved coordinates will be linked to the database, and using the NGS-approved transformation parameters and velocity model, made available in either ITRF or NAD83 at an NGS-published epoch or at any user-selectable epoch date. Data will be output from the online interface through interactive data pages as exists currently, a printable station summary page, and as a complete data table format, such as the Spatial Data Transfer Standard, for a selected set of stations. We expect that this will be an ongoing and evolving research and development effort that will continue in future fiscal years.

Anticipated Project Tasks

- Develop software to expand output formats of SIM version 1.3.
- Develop database links between SOPAC data processing and NGS transformation and velocity models.
- Develop closer linkage between SOPAC's SCOUT and NGS' OPUS coordinate generators.
- Develop closer linkage between the databases of NGS and SOPAC, by means of (but not limited to) the UNAVCO GPS Seamless Archive (GSAC).
- Prepare and distribute interactive training CD for new users.

Total budget: \$183,000

2. Height Network: San Joaquin Valley

Our goal is for a complete data set of NAVD88 heights to be computed for the California CORS network, according to the CSRC Draft Master Plan. This goal will be achieved incrementally as funds become available. In FY2001, we are performing height modernization projects in southern California and the San Francisco Bay area. This year, we will award one large contract in Northern California, specifically in the San Joaquin Valley, which suffers from a very poor vertical network. After a thorough review of existing leveling data, we will measure by leveling, orthometric heights for a subset of CORS sites (see task 3) and for existing ground monuments as available in the project area. These surveys, in combination with NGS geoid models, will provide the vertical reference network. This task will be performed in accordance with the Draft Master Plan, including a mix of active CORS stations and passive monuments (at a nominal spacing of 7 km). The CSRC will look for local, statewide, and science-based partners for cooperative projects to expand the CORS network in this region (see task 3), according to the design outlined in the Draft Master Plan.

Anticipated Project Tasks

- Review of existing vertical GPS campaigns to refine processing procedures for orthometric height determination.

- Assemble existing leveling data to CORS and plan new leveling ties.
- Review CORS and survey-mode GPS data and quantify geographic weaknesses (i.e. geoid model, limited network constraints). Collect and archive leveling and GPS ties to selected CORS by contract to private survey firms.
- Populate the coordinate database with derived NAVD88 heights and estimated errors.
- Provide seamless links to conclusions through SIM.
- Develop a work plan and cost estimate to complete the leveling and other work necessary to achieve a specific confidence level for orthometric heights throughout California (the confidence level might vary by regions) – based on the experience and knowledge gained from this effort.

Total budget: \$283,000

3. CORS Densification (San Joaquin Valley)

This task is directly related to task 2 and will consist of promoting the establishment of CORS in the San Joaquin Valley, consistent with the Master Plan. Since CSRC funds are very limited, the actual cost of the CORS would be paid for by partners, along the lines of the Orange County Continuous Real-Time Network (OCR TN) in FY2001. We will solicit cooperative agreements with partners, such as Caltrans, California Counties, BARD, and the Earthscope/PBO project, etc.

Anticipated Project Tasks

- Provide technical assistance and possibly installation oversight if appropriate for CORS.
- Develop requirements, specifications, and cost estimates for an acceptable low-cost CORS.
- Develop sample agreement terms.
- Investigate the use of wide-area RTK methods for the CORS.

Total budget: \$41,000

4. San Francisco Bay CORS-Only Network

This task is a continuation of height modernization being conducted in the south San Francisco Bay Area with FY 2001 funds, that will provide GPS coverage to approximately 30 stations in the South San Francisco Bay with observations and data processing in accordance with the NGS 2-cm Ellipsoid Height Guidelines http://www.ngs.noaa.gov/PUBS_LIB/NGS-58.html. The network will include sufficient ties to tidal benchmarks and NAVD88 benchmarks to allow accurate modeling of these surfaces in relation to GPS-derived ellipsoid heights. In FY2002 we will work cooperatively with UC Berkeley (operators of BARD) and local agencies to expand the local CORS network. Data processing, management, and high-speed communications equipment will be installed in the region (as funds permit) for eventual implementation of a real-time GPS system over this region, similar to FY2001's Orange County Real-Time Network (OCR TN). This task is consistent with the vision outlined in the Draft Master Plan of a statewide reference network based on CORS stations, with CORS-only networks in major metropolitan regions.

Anticipated Project Tasks

- Generate local support and financial assistance to establish required additional CORS.
- Design the CORS-only infrastructure, including additional CORS sites as designated in the Master Plan.
- Implement the CORS-only infrastructure to the extent financial assistance is acquired.
- Demonstrate the capabilities of CORS-only surveying and the potential of real-time GPS surveying.
- Provide orthometric height corrections for surveyors within the region.
- Educate users of the system.

Total budget: \$120,000

5. Southern California Real-Time GPS Network

This task will expand the OCR TN-type real-time system being developed in FY2001 into Western Riverside County, in collaboration with the Riverside County Flood Control and Water Conservation District, the Surveyor's Office of the Riverside County Transportation Department, and the Southern California Integrated GPS Network. As in OCR TN, the central facility will receive data continuously from the upgraded CORS sites. The data will be analyzed for integrity, stored on data servers, and RTCM data will be provided by means of wireless links to support RTK surveys. A user will be able to compute orthometric heights in the field, based on NGS geoid models and

corrector surfaces computed from the CORS sites as orthometric heights are determined for these sites. This approach will be tested in Orange County, which has an extensive horizontal and vertical control network.

Anticipated Project Tasks

- Expand the southern California real-time GPS network to Western Riverside County, which has a good concentration of SCIGN stations.
- Provide technical consultation to state and local surveyors.
- Test the use of geoid models and corrector surfaces in Orange County.
- Provide orthometric height corrections for surveyors within the region spanned by the adjacent real-time networks.
- Prepare and post a report that describes the project, implementation costs (for other, similar networks), survey results, benefits, and existing and potential users.

Total budget: \$91,000

6. Subsidence Monitoring: Interferometric Synthetic Aperture Radar (InSAR)

This is a continuation of FY2001 efforts. Investigators at SIO and USGS have demonstrated that InSAR can be an effective tool for monitoring land subsidence, an important factor in maintaining a modern vertical reference network. It is quite difficult to develop models for vertical deformation, unlike horizontal deformation and models such as NGS' HTDP. Furthermore, GPS observations and traditional measurements such as leveling are too expensive for monitoring vertical deformation. InSAR provides excellent spatial resolution with good precision to identify, map, and quantify regions of subsidence. On the negative side, this technique may not be suitable in areas that are subject to signal de-correlation (such as agricultural land). This task will apply techniques being developed in the scientific community to the problem of defining a vertical reference system for the CSRC. The focus in FY2001 was in Los Angeles and Orange Counties where there is significant land subsidence. This year, we will investigate new InSAR techniques that are applicable in agricultural areas, where the bulk of subsidence in California occurs. In particular, we will focus on Yolo County where subsidence is known to occur, and where extensive GPS measurements are available.

Anticipated Project Tasks

- Develop and test InSAR capabilities and effectiveness in determining subsidence (focus on Yolo county).
- Prepare draft guidelines and training materials related to height modernization activities.
- Provide Web-based survey reports to land surveyors working in the areas of focus.

Proposed budget: \$50,000

7. Education and Outreach

Support for at least two town meetings focusing on height modernization, in cooperation with NGS, the CSRC annual meeting, and the general E&O activities of our two Professional Land Surveyors and other CSRC staff.

Proposed budget: \$40,000

8. CSRC Operations/Management

This task covers the basic costs of operating and managing the CSRC operational center at Scripps. This includes 12.6 months of salary distributed over 6 permanent staff members (Bock, Gilmore, Jamason, Malveaux, Pike-Humphrey, and Haak), accounting for 2/3 of the budget for this task. The remaining 1/3 is for supplies.

Total budget: \$190,000

2002 Summary Budget and External Contracting Allocations

	Total	Subcontracts and Professional Services (including IDC)
1. CSRC Data Portal	183,000	40,000
2. Height Network (San Joaquin Valley)	283,000	231,000
3. CORS Densification (San Joaquin Valley)	41,000	30,000
4. San Francisco Bay CORS-Only Network	120,000	84,000
5. S. California Real-Time GPS Network	91,000	0
6. Subsidence Monitoring: InSAR	50,000	0
7. Education and Outreach	40,000	28,000
8. CSRC Operations/Management	190,000	0
Total	998,000	413,000

Note: All numbers are rounded to nearest thousandth.

Budget Summary (2002 Budget - This Year)

Category	Tasks	Amount	%
Salaries and Benefits	All	\$427,000	43
Subcontracts & Professional Services	1-4,7	\$413,000	41
Equipment	1	\$53,000	5
Travel and Supplies	All	\$105,000	11
Total	All	\$998,000	100%

Note: Amounts include indirect costs

Budget Summary (2001 Budget - Last Year)

Category	Tasks	Amount	%
Salaries and Benefits	All	\$496,000	50
Subcontracts & Professional Services	2-5	\$249,500	25
Equipment	1-3, 5	\$174,500	17
Travel and Supplies	All	\$78,000	8
Total	All	\$998,000	100%

Note: Amounts include indirect costs