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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

TRANSFORMING IDEAS INTO SOLUTIONS

Research Notes

Statewide 3-Dimensional Motion Analysis for Optimal CTSRN Performance and Geospatial Data Management

Researching and developing regional boundaries for CTSRN sub-networks and developing configurations for minimal maintenance and maximum accuracy of the sub-networks. assessment of bridges.

Right of Way and Land Surveys

April 2025

Project Title: Accuracies and Specifications for the Caltrans' Spatial Reference Network (CTSRN) Project

Task Number: 4317

Start Date: June 30, 2024

Completion Date: January 29, 2026

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WHAT IS THE NEED?

The California Department of Transportation (Caltrans) Spatial Reference Network (CTSRN) is the Department's precise, positioning Global Navigation Satellite System (GNSS) that is currently used by Caltrans Divisions of Land Surveys, Construction, Maintenance, and other divisions and programs to accurately locate features for highway improvement projects and asset management.

In a geological context, California is situated on a major fault line (tectonic plate boundary) along with numerous other earthquake fault zones and is subject to areas of severe subsidence due to natural and resource extraction effects. This surface motion causes a deterioration of a few inches annually in the positional and spatial accuracy of the CTSRN and the Caltrans' Legacy Geodetic control network. With some of these effects having predictable trends, Caltrans needs research to investigate possibilities and develop models that will allow isolation of regions/areas of consistent relative movement.

WHAT ARE WE DOING?

Through collaboration with UC San Diego Scripps Orbit and Permanent Array Center (SOPAC), Caltrans Right of Way and Land Surveys, and DRISI, the research will investigate strategies to develop regional boundaries for the CTSRN sub-networks using Continuous GNSS (CGNSS) station data. The investigation involves a comparative analysis on combinations of approaches to determine the optimal strategy, which includes an accompanying, draft 3-D digital

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map. Upon determination of the optimal strategy, the research team will perform a geophysical analysis of daily GPS-derived displacement time series within the SOPAC database. This analysis will enable the researchers to identify regions with similar deformation motion patterns with time and create a series of 2-D and 3-D digital maps. Combining the series of digital maps together will quantify 4-D crustal motions in California.

Building on the created series of 2-D and 3-D digital maps and 4-D crustal motions, the university research team will look at past earthquakes and high-seismic risk areas to assess the effects on the composition of the regional boundaries. The SOPAC researchers will collaborate with Right of Way and Land Surveys for their guidance on the current number and geographic distribution of CTSRN stations and expansion plans of the network. Next, the research team will construct models to predict movement in order to retain CTSRN accuracy over time. The researchers will utilize the data from the models to create a finalized set of 3-D digital maps, including velocity data, regional boundaries, time intervals, and source data locations to prepare recommendations for optimal CTSRN sub-network boundaries in California.

WHAT IS OUR GOAL?

The goal is to minimize maintenance and maximize the relative accuracy of CTSRN sub-networks through the development of configurations and regional boundaries for the sub-networks using CGNSS station data. The end product of these developments will be in the form of digital maps and will take into consideration for geology, landforms, subsidence, and plate tectonics.

WHAT IS THE BENEFIT?

Determination of optimized regions from the research product, digital map, will improve the internal accuracy and consistency of the CTSRN, Caltrans' geodetic control networks, and the digital and geospatial data products based upon these networks. The project will reduce the level of maintenance by reducing positional integrity assessment that is currently required to maintain optimal CTSRN performance. This research will improve efficiencies by identifying focus areas and regular time intervals for CTSRN and control network re-adjustments, thereby reducing efforts spent on areas that are less impacted by ground motion. This will significantly reduce costs and resources by minimizing preliminary investigations and re-work of control surveys along with efforts dedicated to the positional integrity assessment of the CTSRN. This research will enhance the accuracy and maintenance of geospatial data contained in a statewide common data environment – Geographic Information System.

WHAT IS THE PROGRESS TO DATE?

Caltrans Division of Procurement and Contracts and the Department of General Services executed the contract on March 10, 2025. The Caltrans task manager issued a written, official Start Work Order to the university researcher.

The next immediate steps for this research are to schedule and conduct a research Kickoff Meeting for May 2025 and determine the best Strain Map parameters for GNSS station clustering.