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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION
TRANSFORMING IDEAS INTO SOLUTIONS

Research Results

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

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

Right of Way and Land Surveys

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

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DRISI provides solutions and knowledge that improves California's transportation system.

WHAT WAS 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 WAS OUR GOAL?

The goal was 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 Continuous Global Navigation Satellite System (CGNSS) station data. The research team achieved and obtained the end product of these developments in the form of digital maps and accounted for geology, landforms,

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subsidence, and plate tectonics.

WHAT DID WE DO?

Through collaboration with UC San Diego Scripps Orbit and Permanent Array Center (SOPAC), Caltrans Right of Way and Land Surveys, and DRISI, the research investigated strategies to develop regional boundaries for the CTSRN sub-networks using CGNSS station data. The investigation involved a comparative analysis on combinations of approaches to determine the optimal strategy, which included an accompanying, draft 3-D digital map. Upon determination of the optimal strategy, the research team performed a geophysical analysis of daily GPS-derived displacement time series within the SOPAC database. This analysis enabled 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 quantified 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 investigated past earthquakes and high-seismic risk areas to assess the effects on the composition of the regional boundaries. The SOPAC researchers collaborated 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 constructed models to predict movement in order to retain CTSRN accuracy over time. The researchers utilized 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 WAS THE OUTCOME?

Results from the research provided Caltrans with a set of optimal regional boundaries (subnetworks) for the CTSRN to support highway improvement projects and increase efficiencies by Survey Department staff. The design, which takes geology, landforms, subsidence, and plate tectonics into consideration, minimizes maintenance and maximizes the relative accuracy of the subnetworks by providing a schedule for updating station coordinates for Caltrans projects and real time kinematic (RTK) users of the CTSRN.

WHAT IS THE BENEFIT?

Determination of optimized regions from the research product, digital map, enhanced 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 reduced the level of maintenance by reducing positional integrity assessment that is currently required to maintain optimal CTSRN performance. This research improved 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 significantly reduced 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 enhanced the accuracy and maintenance of geospatial data contained in a statewide common data environment – Geographic Information System.

LEARN MORE

To view the complete report:

https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/final-reports/final-report-4317-a11y.pdf

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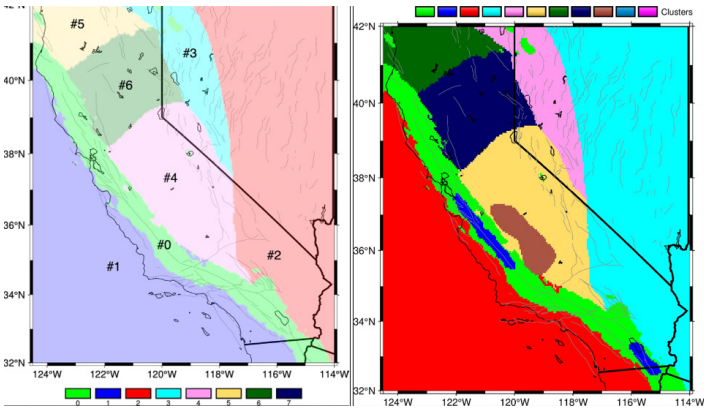


Image 1: Optimal subnetworks. Final subnetwork design for CTSRN and CRTN configurations (nearly identical and represented by a single map). (Left) Horizontal clusters; (Right) Horizontal and vertical clusters, which includes Cluster #8 in the Central Valley. The distinct blue regions along the San Andreas fault are folded into Cluster #0 covering the San Andreas fault system in the (Right) map. Cluster #3 is outside of California's boundaries, so its sliver in the northeast corner of the state is folded into Cluster #5 in the (Left) map.

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