CALIFORNIA DEPARTMENT OF TRANSPORTATION APPLICATION OF GPS TECHNOLOGY

CIVIL GPS SERVICE INTERFACE COMMITTEE MEETING

SACRAMENTO, CA

AUGUST 24, 2011

Presenter: James M. Harcharik PLS

Office of Land Surveys

CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)

CALTRANS IS RESPONSIBLE FOR THE DESIGN, CONSTRUCTION, MAINTENANCE, AND OPERATION OF THE CALIFORNIA STATE HIGHWAY SYSTEM, AS WELL AS THAT PORTION OF THE INTERSTATE HIGHWAY SYSTEM WITHIN THE STATE'S BOUNDARIES.

CALTRANS IS A LEADER IN PROMOTING THE USE OF ALTERNATIVE AND GREEN MODES OF TRANSPORTATION.

CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)

- 15,200-mile state highway system
- 3 intercity rail routes
- Over 20,000 employees
- Over $8 billion Budget in FY 10/11
- Headquarters in Sacramento
- 12 District Offices, Structures Preliminary Investigations Units North and South, Office of Photogrammetry

CALTRANS SURVEYS

- Surveys staff in all districts
- ~650 surveyors
- 100 field crews (typical 3 person)
- Office of Land Surveys
  - Provides functional management of the Caltrans surveying and right-of-way engineering efforts

CALTRANS SURVEYS

- 1986 – Purchase Initial receivers
  - Application – control surveys
- 1995 – Purchase Initial real-time kinematic (RTK) system
  - Application – evaluate technology, topographic mapping
- 1998 – All receivers purchased are Real-Time capable
  - Application – everyday survey tool

CALTRANS SURVEYS

- Today – GPS is an integral part of the Caltrans surveying operations
  - 235 survey/geodetic quality receivers
  - All receivers real-time capable
  - Operating and/or Utilizing real-time networks in many geographic areas of the State
- Tomorrow? – Statewide RTN usage/availability for realization of greater cost savings, newly defined GIS Layers and exponentially growing GIS mapping applications, New Global Navigation Satellite System (GNSS) techniques with Glonass, Galileo, Beidou systems emerging and perhaps others?

WHY GPS?

- Safety
  - Line of sight not required; fewer staff members are exposed to traffic and for shorter time duration compared to conventional techniques.
  - Real Time Network use eliminates need for base receiver lessoning exposure even further.
- Productivity
  - Adoption of GPS surveying tools has helped to achieve ~10% reduction of surveys portion of the Capitol Outlay Support budget overall. Real Time Services help to realize 35% cost savings over traditional GPS techniques.

SPECIFIC ISSUES IN CALIFORNIA

- California
  - Earthquakes
  - Crustal Motion / Plate Tectonics
  - Subsidence
  - Uplift

GEODETIC CONTROL FOR THE NATION AND CALIFORNIA

- National Geodetic Survey (NGS)
  - The Mission of NOAA's National Geodetic Survey is "to define, maintain and provide access to the National Spatial Reference System (NSRS) to meet our nation's economic, social, and environmental needs."
  - California State Geodetic Advisor – Marti Ikehara

GEODETIC CONTROL FOR THE NATION AND CALIFORNIA

- National Geodetic Survey (NGS)
  - Provides the framework for all positioning activities in the Nation. The foundational elements – latitude, longitude, elevation and velocity form the “Basis”on which subsequent mapping is related to the NSRS.

GEODETIC CONTROL FOR CALIFORNIA

- California Spatial Reference Center (CSRC)
  - Established in 2000
  - Scripps Institution of Oceanography (SIO) University of California – San Diego (UCSD)
  - Director – Dr. Yehuda Bock

GEODETIC CONTROL FOR CALIFORNIA

- CSRC (Continued)
  - Goal
    - Provide the necessary geodetic services to ensure the availability of accurate, consistent, and timely spatial referencing data
    - Establish and maintain the California Spatial Reference Network (CSRN) as the official geodetic reference network for California (PRC Section 8855).
    - Monitor temporal changes in geodetic coordinates due to tectonic motion, seismic activity, volcanic deformation, and land subsidence

CALTRANS Typical Static or Fast Static GPS Control Survey Applications

- Geodetic Control Densification
- Corridor and Project Control
- Mapping/Topographic Control
- Landnet/Cadastral Control
- Airborne GPS/Photogrammetry Control
- Construction Reference Control

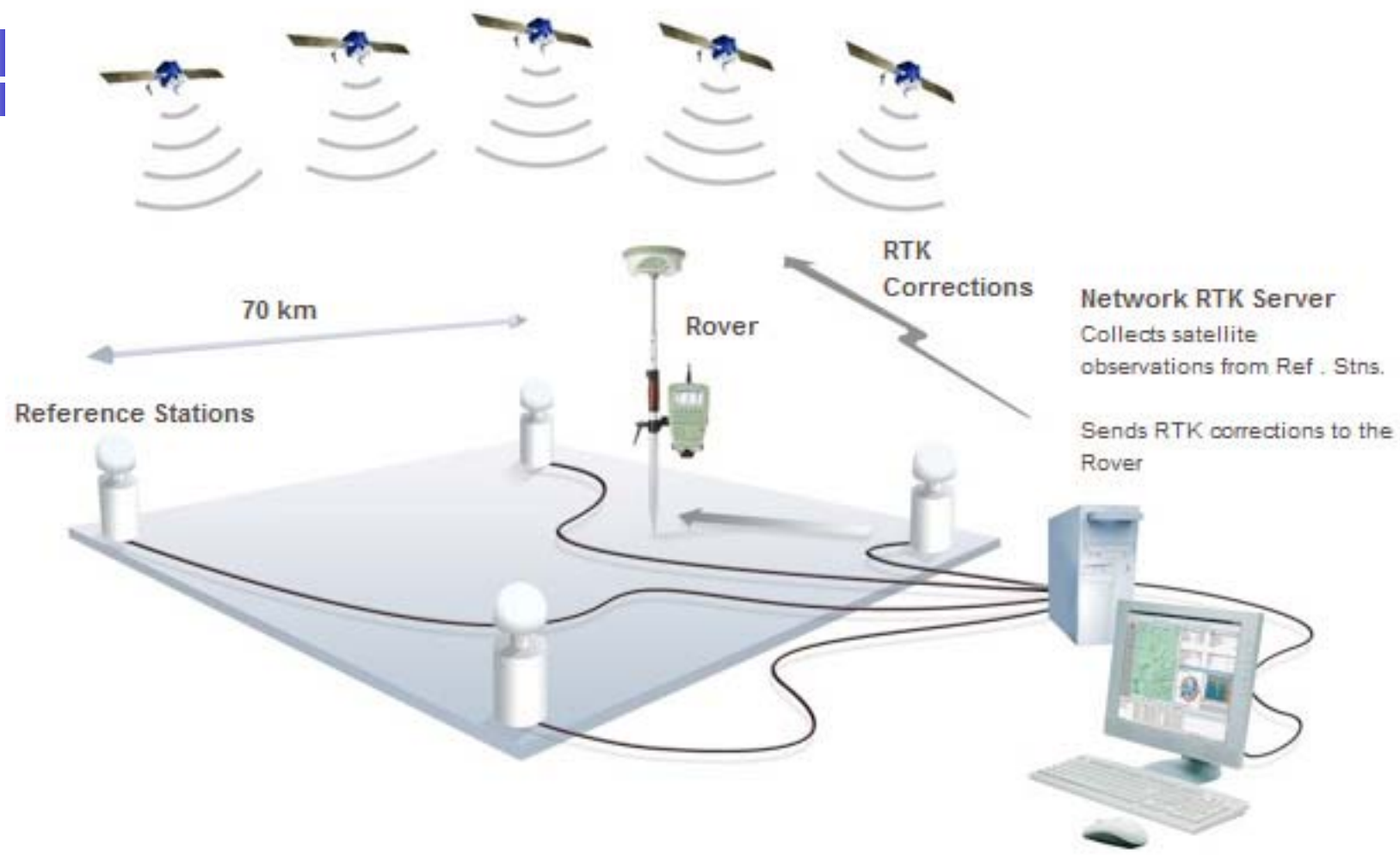
CALTRANS Project Specific Fast Static or Real Time GPS Survey Applications

- Topographic Surveys
- Hydrographic Surveys
- Construction Stakeout
- Environmental Surveys
- Archaeological Surveys
- Utility Location/relocation
- Landnet / Right of Way

Real Time Network (RTN)

A Network of permanently installed, continuously operating GPS/GNSS Reference Stations

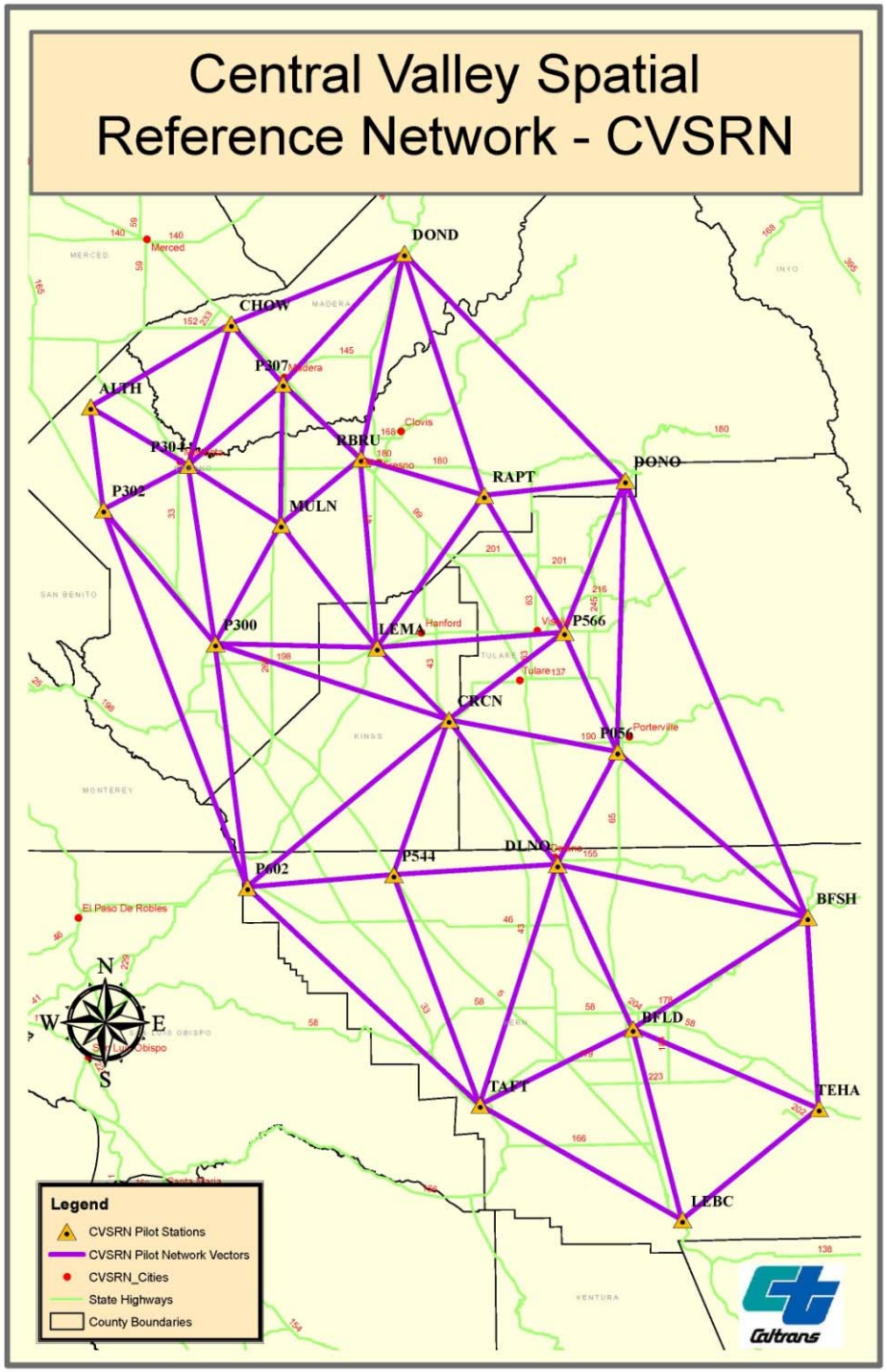
Real Time Networks



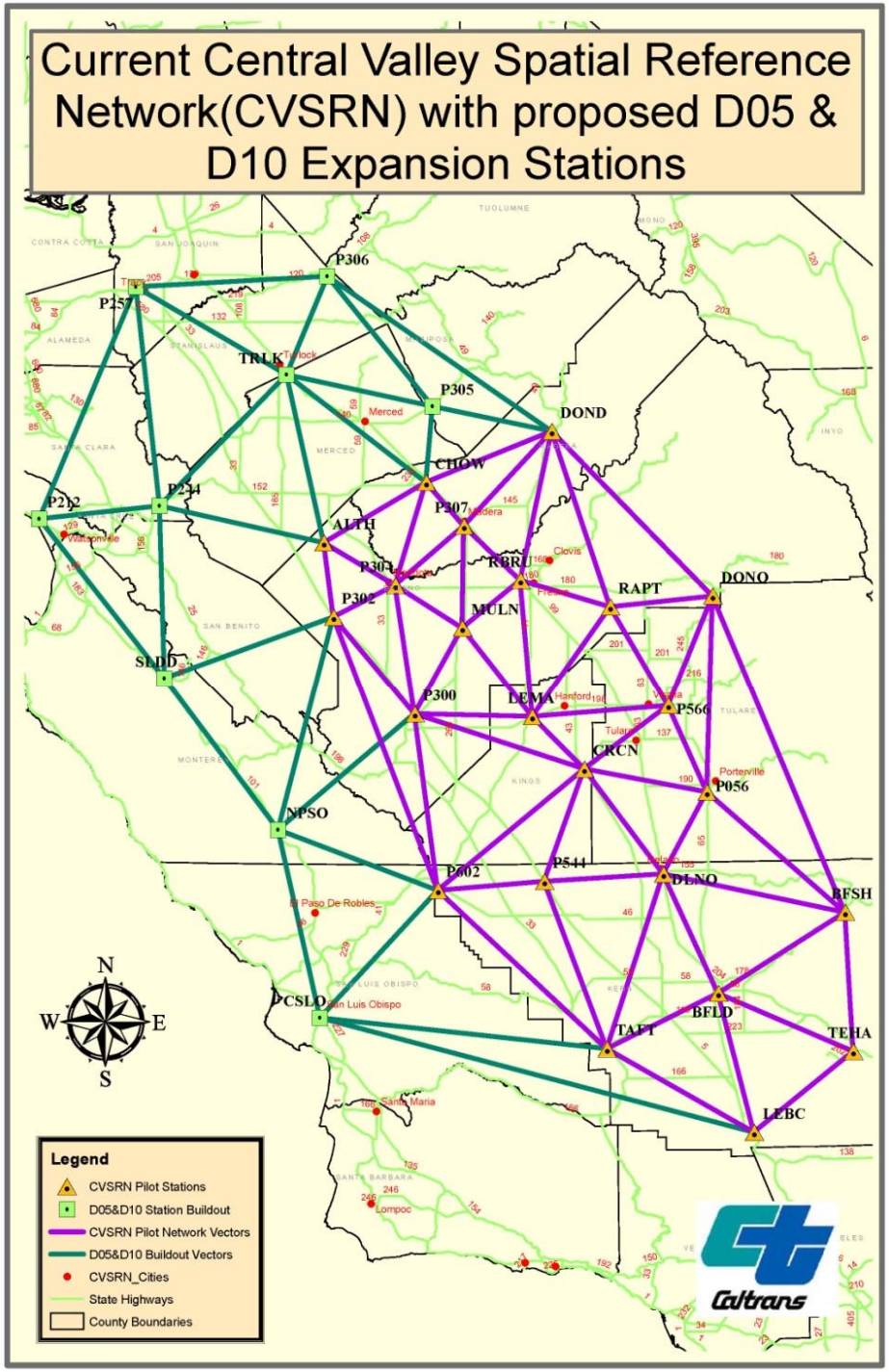
CALTRANS Primary Real Time Networks Used

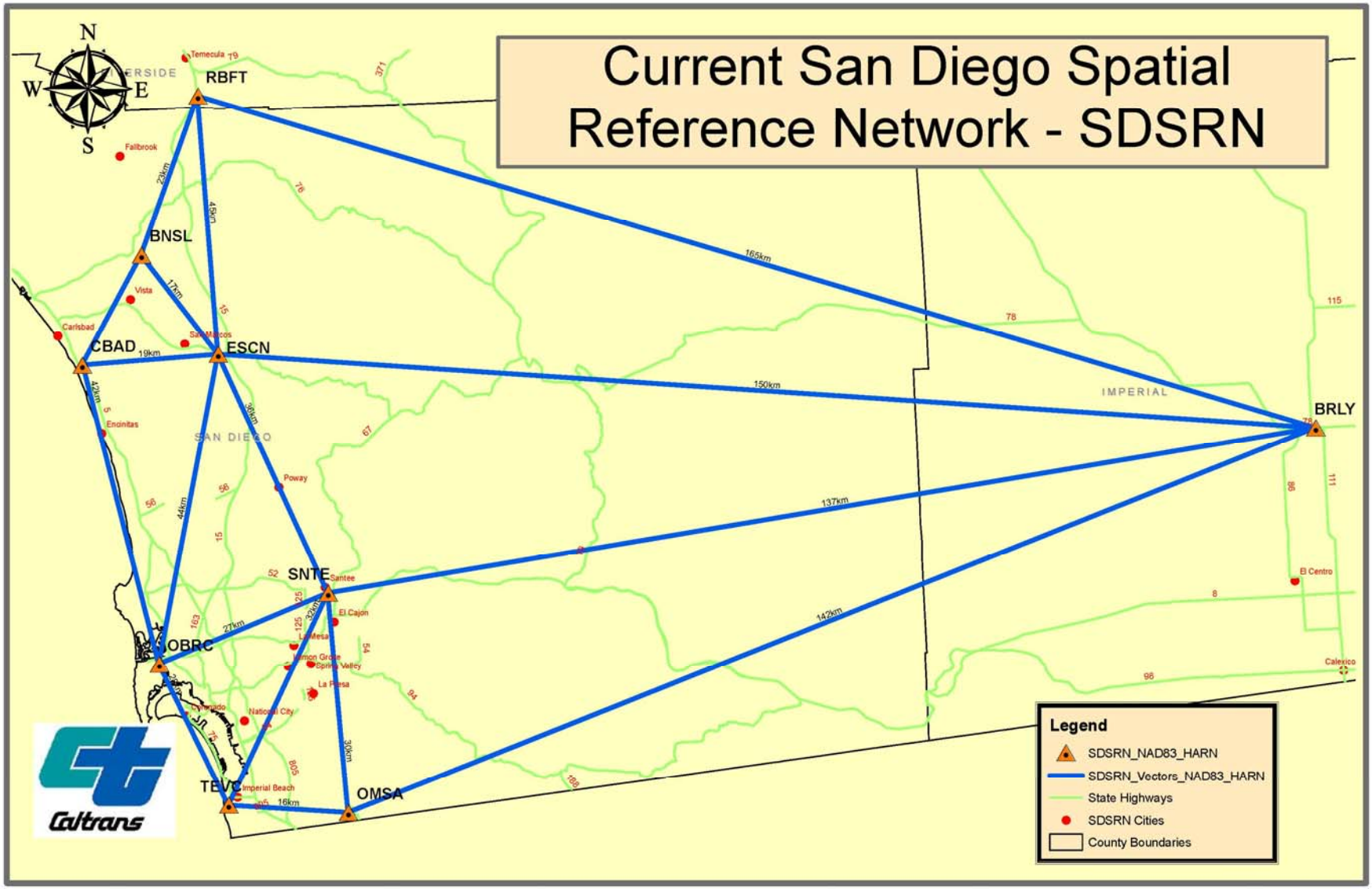
- Central Valley Spatial Reference Network (CVSRN) Operated by District 6
- San Diego Spatial Reference Network (SDSRN) Operated by District 6 & 11
- California Real Time Network (CRTN) Operated by California Spatial Reference Center

Central Valley Spatial Reference Network - CVSRN

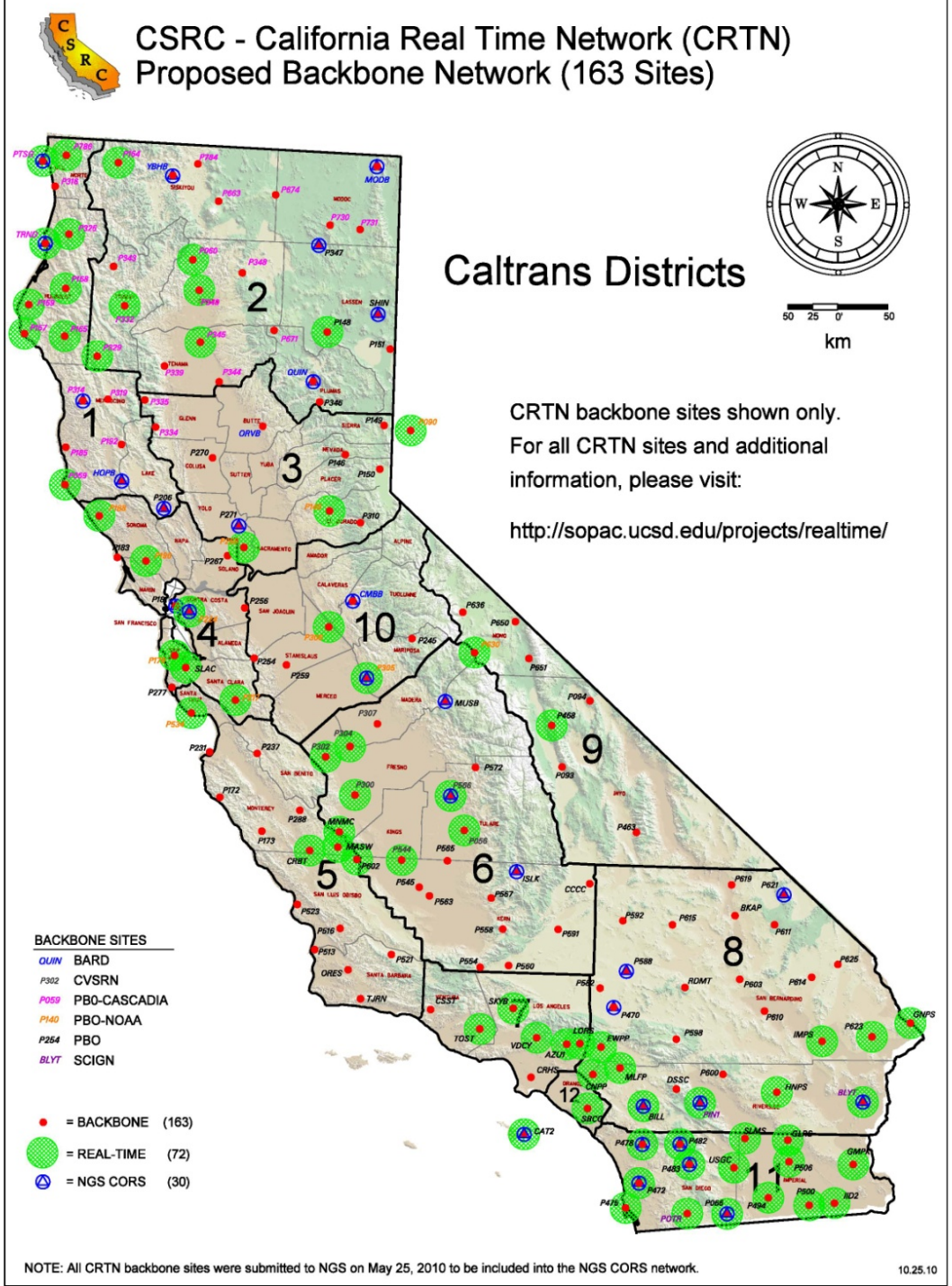


Current Central Valley Spatial Reference Network(CVSRN) with proposed D05 & D10 Expansion Stations





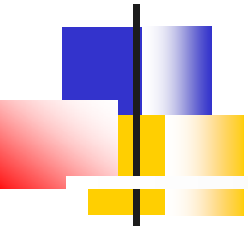
Caltrans Improves Mobility Across California

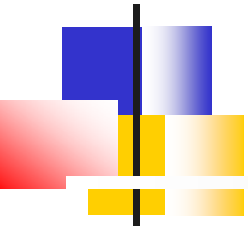

CSRC - California Real Time Network (CRTN)
Proposed Backbone Network (163 Sites)
Caltrans Districts
N
W
E
S
50 25 0 50
km
CRTN backbone sites shown only.
For all CRTN sites and additional information, please visit:
http://sopac.ucsd.edu/projects/realtime/
1
2
3
4
5
6
7
8
9
10
12
BACKBONE SITES
QUIN BARD
P302 CVSRN
P059 PBO-CASCADIA
P140 PBO-NOAA
P254 PBO
BLYT SCIGN
= BACKBONE (163)
= REAL-TIME (72)
= NGS CORS (30)
NOTE: All CRTN backbone sites were submitted to NGS on May 25, 2010 to be included into the NGS CORS network.
10.25.10

Other Real Time Networks Used

- Plate Boundary Observatory (PBO)
- Orange County Real Time Network (OCRTN)
- San Diego County Real Time Network (SDCRTN)
- California Surveying Virtual Survey Network (CSVSN)
- CALVRS Real Time Network
- TopNEXT (Topcon)
- SmartNet (Leica)

OTHER CALTRANS APPLICATIONS OF GPS TECHNOLOGY





AIRBORNE GPS

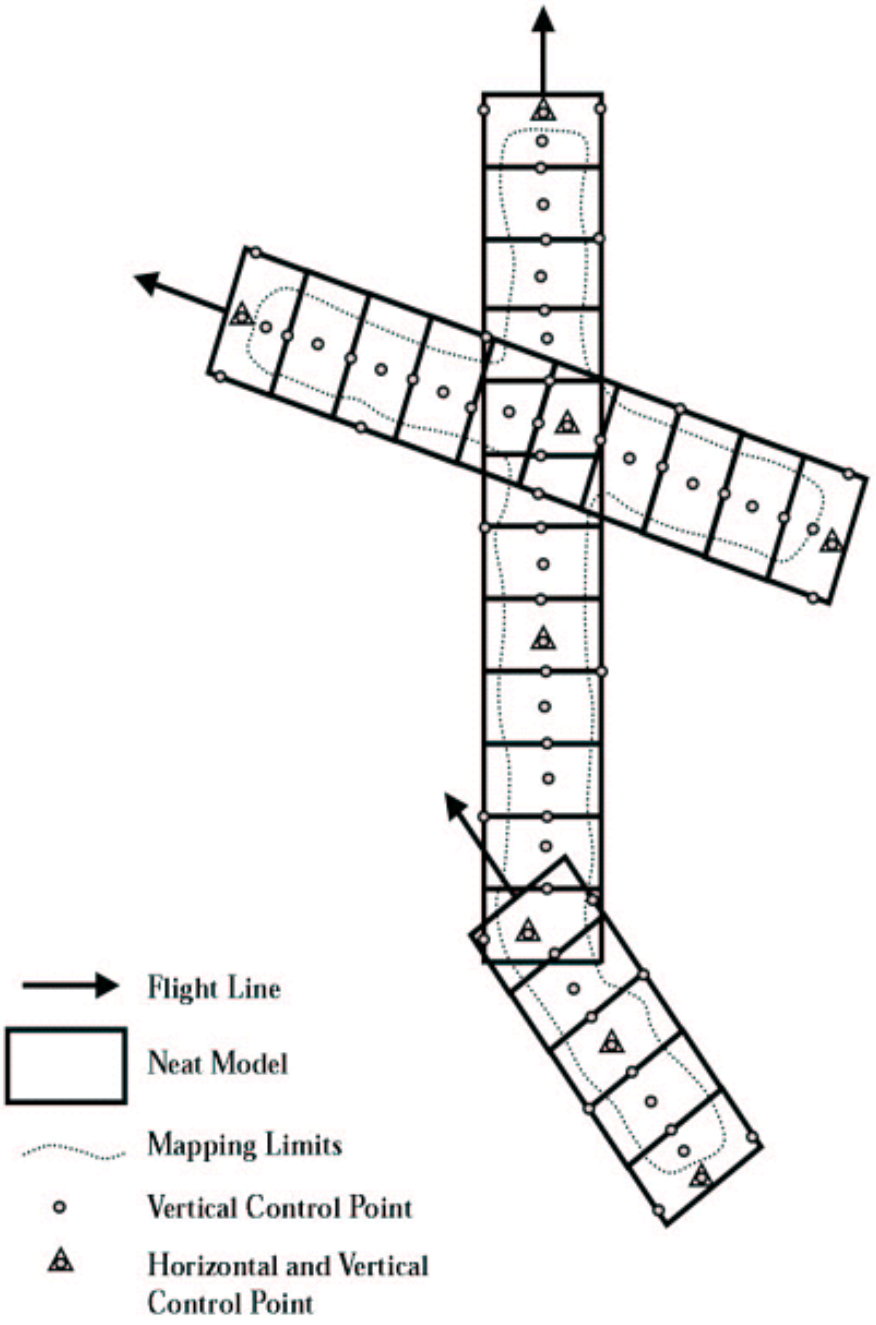
Conventional Photo Control

3 Targets per model along CL

1 Wing Point every 4 models

1 HV Point every 5 models

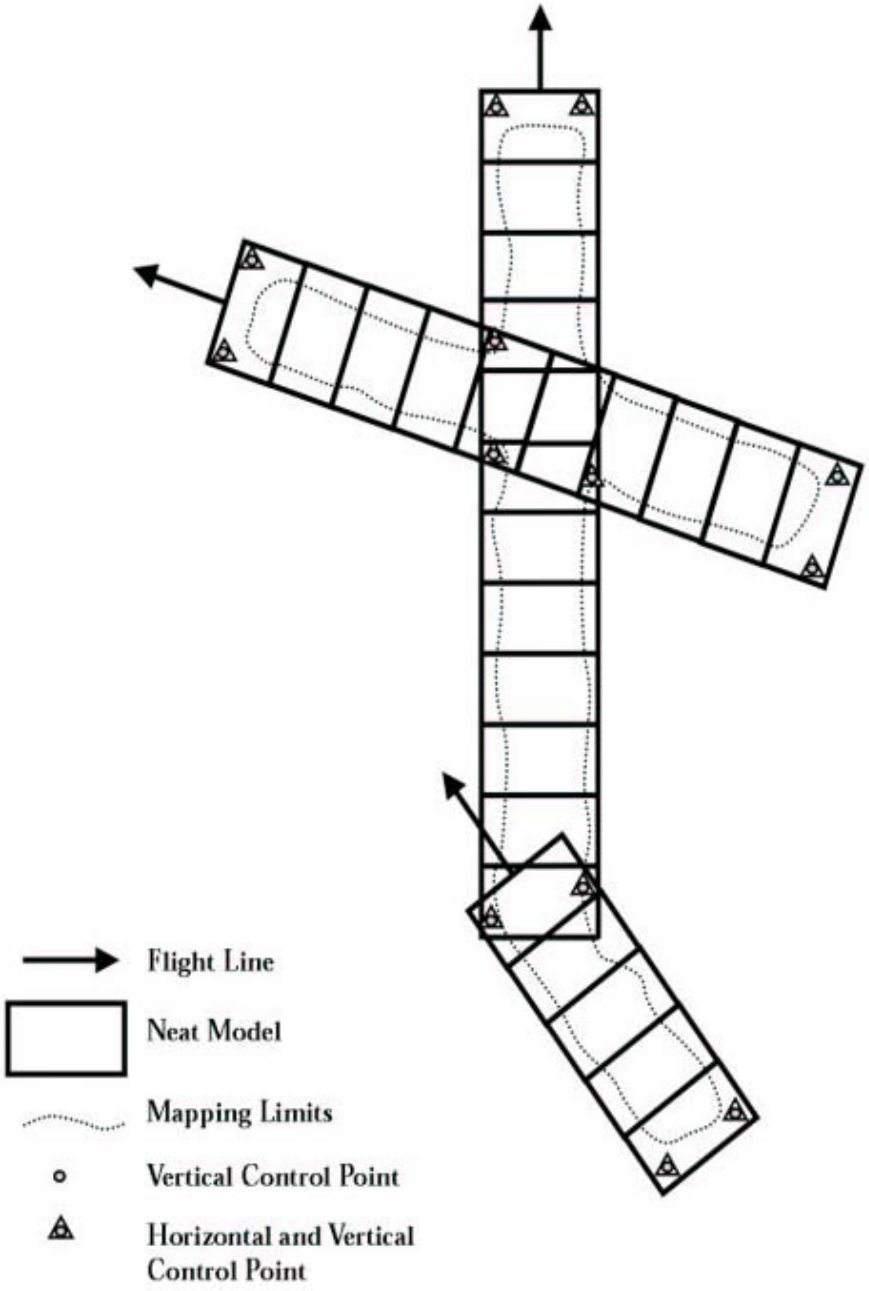
3rd Order Control




13 11:01 AM

Airborne GPS

Reduces by 80% the need for on-the-ground photo control



AIRBORNE GPS

CONCLUSION

ABGPS has proven to be an excellent tool in providing photogrammetric mapping for transportation projects and reducing the danger to Caltrans surveyors

GPS BASED DRIVER ASSISTANCE SYSTEM

DELIVERED JUNE 2008

-Satellite Based Augmentation System (SBAS)

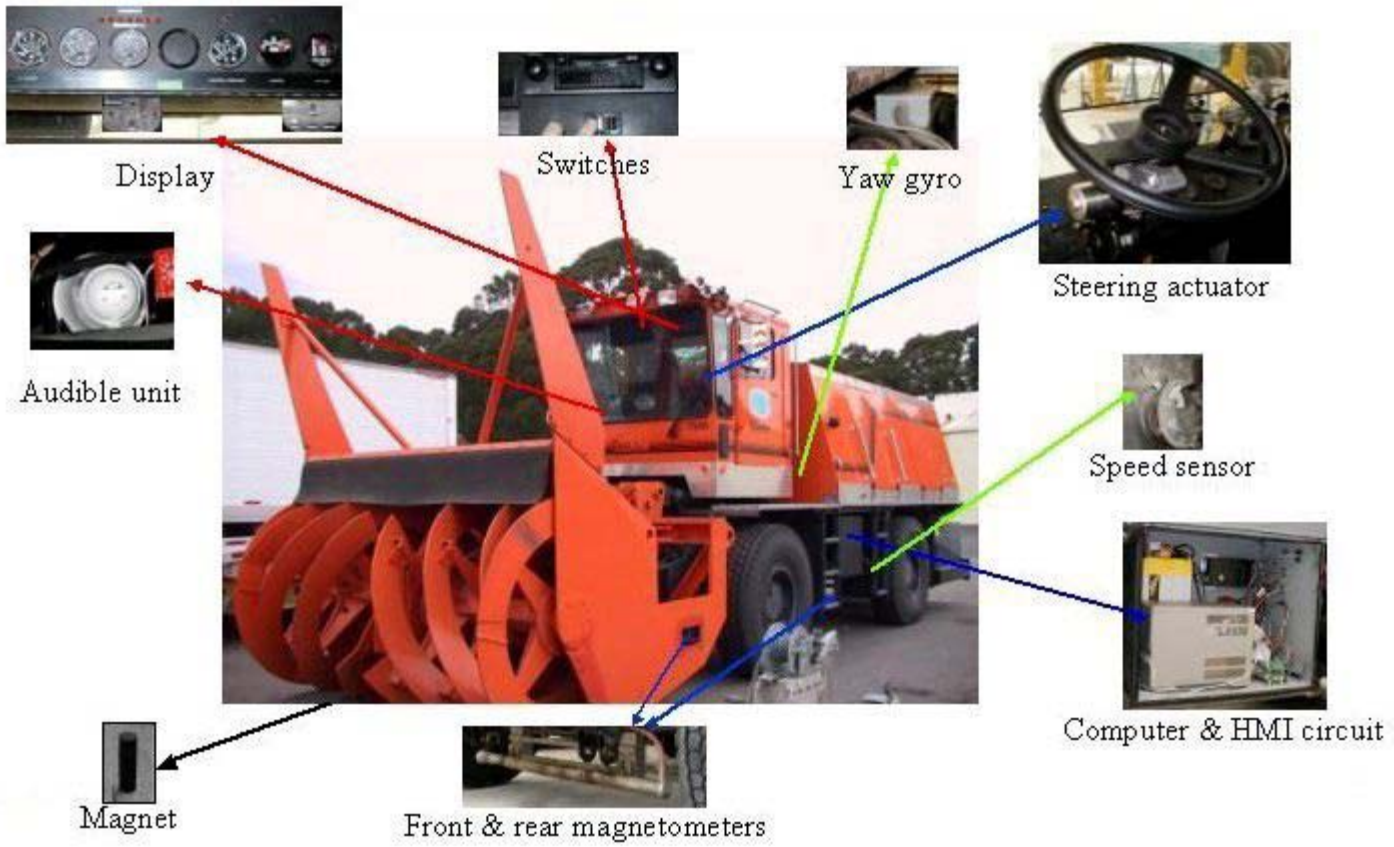
Application: Snowplow Guidance for opening Mountain Passes

GPS BASED DRIVER ASSISTANCE SYSTEM

4 inch (10cm) accuracy

Requires accurate underlying GIS base map which includes: highway centerline, hinge point - outside edge of shoulders, lanes, roadside features (obstacles, assets)

Differential Carrier Phase GPS and Magnetometer Combined



Differential Carrier Phase GPS and Magnetometer Combined

Caltrans Improves Mobility Across California

Differential Carrier Phase GPS and Magnetometer Combined

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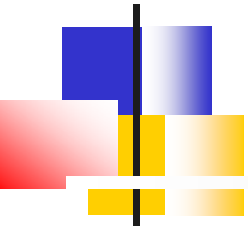
Real Time GPS Monitoring



Translab (August 2003)

-RTK GPS w/ wireless telemetry

Application: Real Time Monitoring of deformation/movement due to earthquakes or active landslides and Structures Monitoring

Real Time GPS Monitoring

- High-precision Real Time Kinematic GPS and wireless communications.
- Remote Monitoring of Landslides (1200 miles of landslide prone Highway corridors, approx. 200 slides and 10 road closures per year =$10 million for clean-up and mitigation efforts)
- Bridge Monitoring applications

Confusion Hill Bridge (Humboldt)

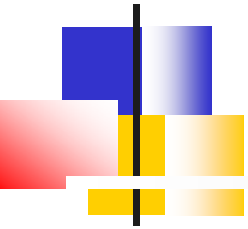
Real Time GPS Monitoring

- Measure accurate vector displacement relative to a stable satellite-based reference framework.
- Relatively inexpensive system to deploy in remote locations using autonomous power system, wireless spread spectrum data transceivers and internet technologies. Low maintenance cost.

Real Time GPS Monitoring

- Tests in Japan demonstrate flexibility and stability of system.
- Conventional Surveying only establishes conditions before and after events while Real Time GPS Monitoring yields continuous data which can be further analyzed as to before, during and after conditions of the event.

Real Time GPS Dispatching / Vehicle Tracking



Implemented January 2009

Developed in CT partnership w/ Cal Poly Pomona

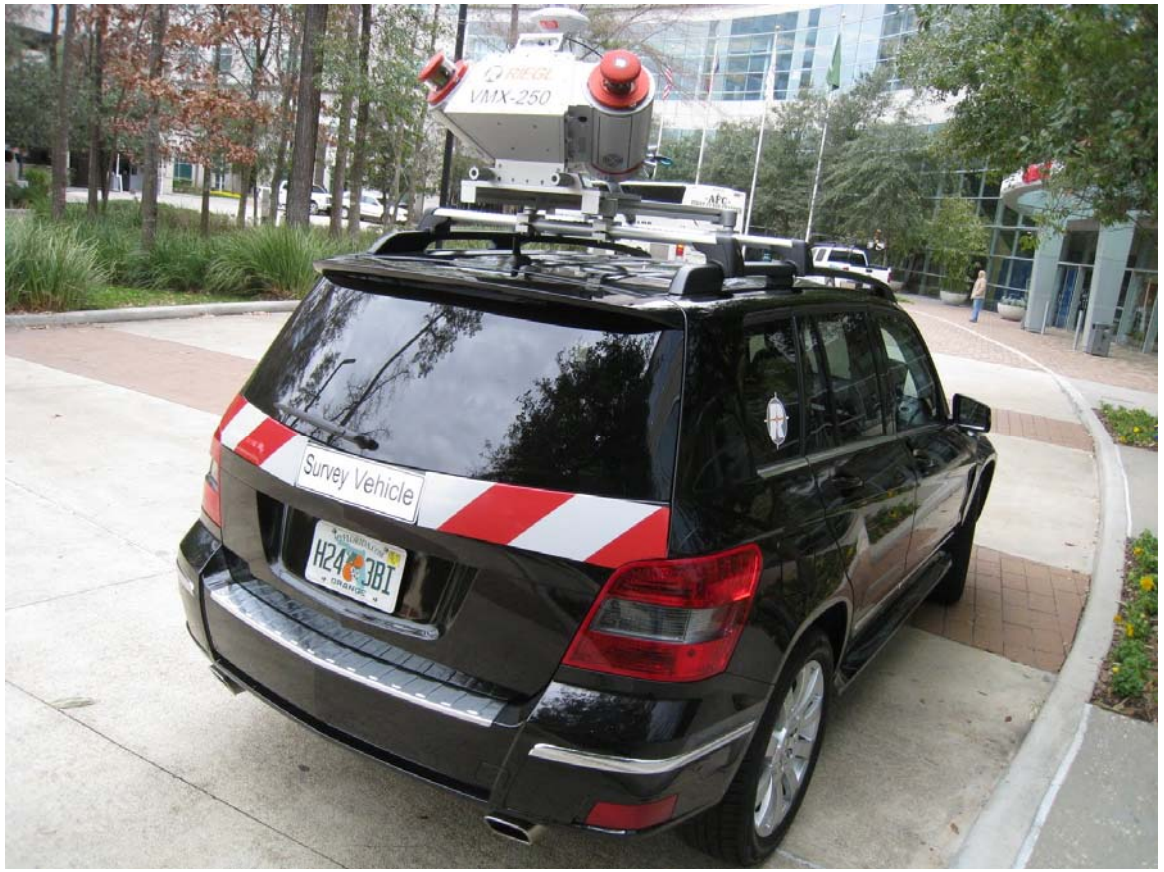
-Small Transit System

Real Time GPS Dispatching / Vehicle Tracking

Application: Tracking Buses and determining time of arrival at stops. Message boards alert riders in Real Time. Benefits Dispatchers and Managers in determining route and schedule issues. Can send add'l Buses or replacements

LASER Scanning (Reliant on GPS for Horizontal Control)

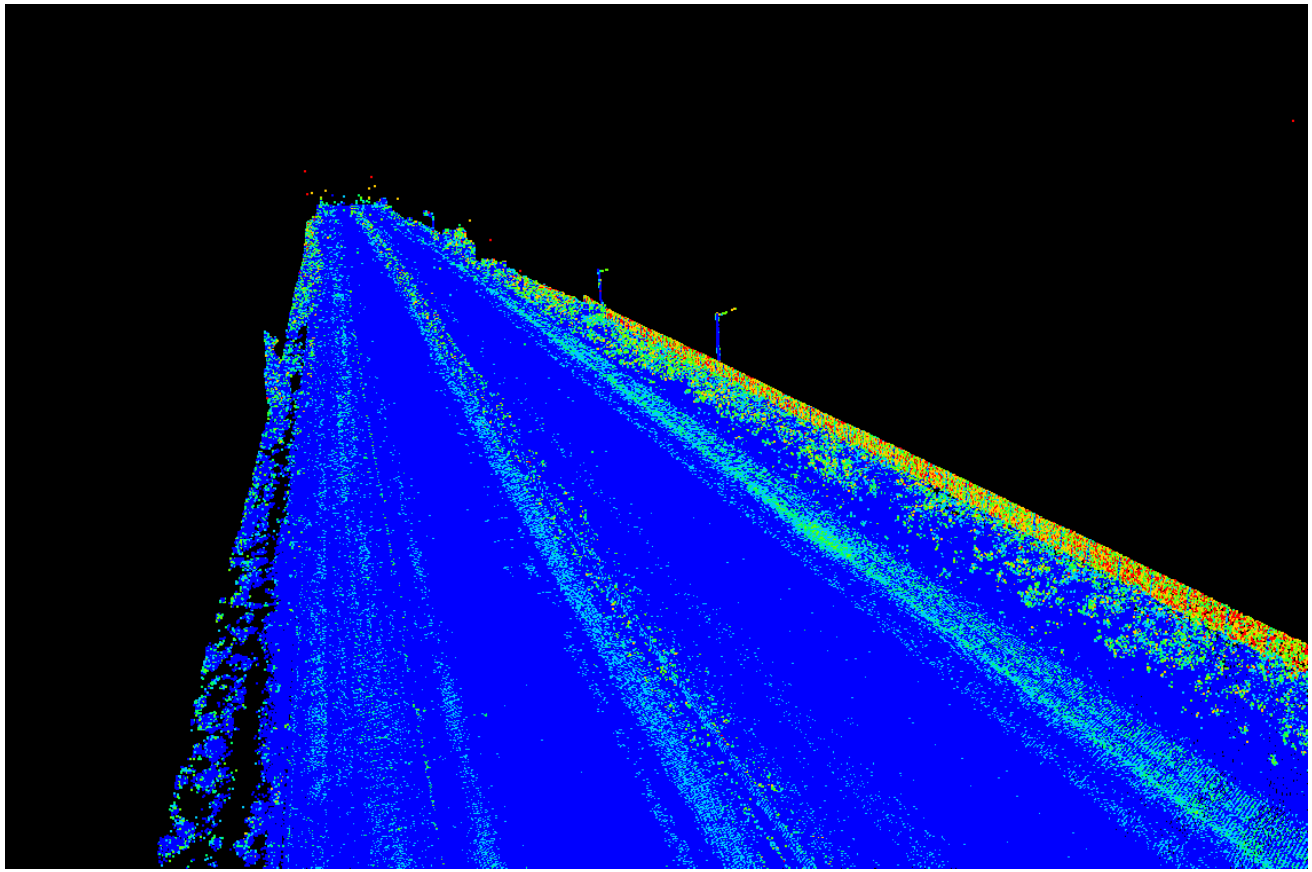
Mobile LASER Scanning (Reliant on GPS for Horizontal Control)



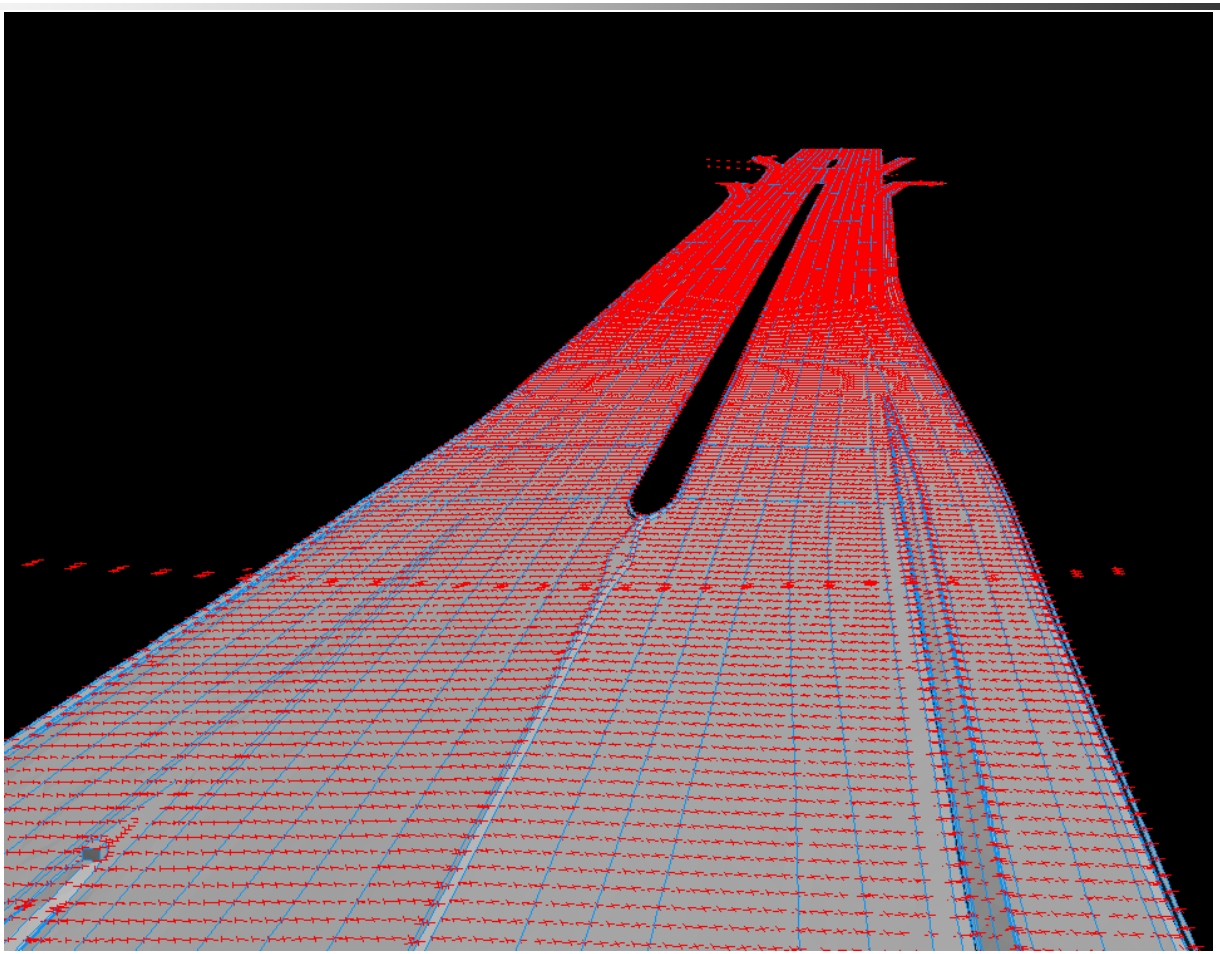
Caltrans Improves Mobility Across California

LASER Scanning Example
Doyle Drive – San Francisco

Laser Scanning Point Cloud



Vertical Component Verification (precise level data used for vertical)



Caltrans Improves Mobility Across California

Comparison of Stationary Scan vs. Mobile Scan Vertical Data

Stationary Point Cloud X	Y	Z	Horz Diff	Vert Diff	VD^2
5998065	2121090	27.469	0	-0.080	0.006
5998065	2121093	27.501	0	0.017	0.000
5998065	2121096	27.451	0	-0.044	0.002
5998065	2121099	27.429	0	-0.031	0.001
5998065	2121102	27.392	0	-0.068	0.005
5998068	2121072	27.618	0	-0.002	0.000
5998068	2121075	27.603	0	-0.007	0.000
5998068	2121078	27.578	0	-0.012	0.000
5998068	2121081	27.551	0	-0.009	0.000
5998068	2121084	27.516	0	-0.014	0.000
5998068	2121087	27.48	0	-0.008	0.000
5998068	2121090	27.44	0	-0.021	0.000
5998068	2121093	27.408	0	-0.022	0.000
5998068	2121096	27.378	0	-0.051	0.003
5998068	2121099	27.331	0	-0.052	0.003
5998068	2121102	27.312	0	0.048	0.002
5998071	2121057	27.511	0	-0.049	0.002
5998071	2121060	27.533	0	-0.032	0.001
5998071	2121063	27.561	0	-0.014	0.000
5998071	2121066	27.569	0	0.007	0.000
5998071	2121069	27.548	0	-0.004	0.000
5998071	2121072	27.534	0	-0.017	0.000
5998071	2121075	27.513	0	-0.024	0.001
5998071	2121078	27.489	0	0.002	0.000
5998071	2121081	27.458	0	-0.008	0.000
5998071	2121084	27.43	0	-0.001	0.000
5998071	2121087	27.397	0	0.002	0.000

Mobile Point Cloud X	Y	Z
5998065	2121090	27.549
5998065	2121093	27.484
5998065	2121096	27.495
5998065	2121099	27.46
5998065	2121102	27.46
5998068	2121072	27.62
5998068	2121075	27.61
5998068	2121078	27.59
5998068	2121081	27.56
5998068	2121084	27.53
5998068	2121087	27.488
5998068	2121090	27.461
5998068	2121093	27.43
5998068	2121096	27.429
5998068	2121099	27.383
5998068	2121102	27.264
5998071	2121057	27.56
5998071	2121060	27.565
5998071	2121063	27.575
5998071	2121066	27.562
5998071	2121069	27.552
5998071	2121072	27.551
5998071	2121075	27.537
5998071	2121078	27.487
5998071	2121081	27.466
5998071	2121084	27.431
5998071	2121087	27.395

Geographic Information Systems

- As the uses of GIS Mapping increase, improved accuracy standards are needed to facilitate acquisition and assembly of geospatial data from various sources to create products that will improve services provided to the public.

Geodetic Control is often used for Geospatial placement of GIS Mapping Data

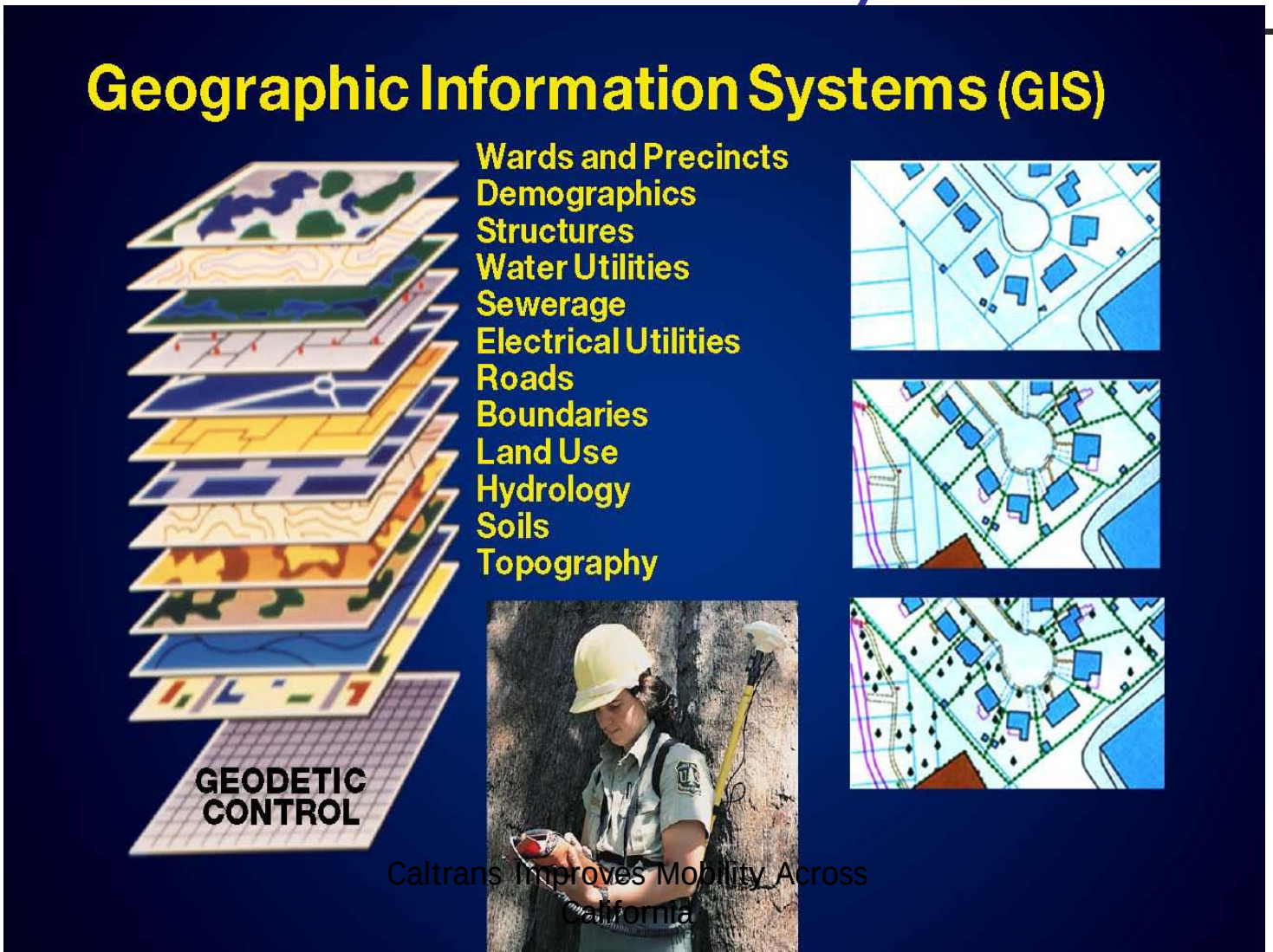
Geodetic Control is one of the National Spatial Data Infrastructure (NSDI) seven core framework themes

Geodetic Control derived from GPS/GNSS observation is often used as the “Basis” for other themes (Layers) to position their data geospatially.

Some Common GIS APPLICATIONS

- Natural Resource Management.
- Environmental Applications which study natural and man-made impacts.
- Restoring/ensuring environmental quality
- Maintenance Asset Inventory
- Pavement Management

Some common GIS Mapping Layers w/ Geodetic Control shown as the Framework or “Base” layer



QUESTIONS?

James M. Harcharik PLS

Senior Transportation Surveyor

(916) 227-7328

james_harcharik@dot.ca.gov

www.dot.ca.gov