CALIFORNIA DEPARTMENT OF TRANSPORTATION APPLICATION OF GPS TECHNOLOGY

CIVIL GPS SERVICE INTERFACE COMMITTEE MEETING

SACRAMENTO, CA
AUGUST 24, 2011
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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.

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California
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
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**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
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

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

Legend:
- CVSRN Pilot Stations
- D05&D10 Station Buildout
- CVSRN Pilot Network Vectors
- D05&D10 Buildout Vectors
- CV/HR Cities
- State Highways
- County Boundaries
Current San Diego Spatial Reference Network - SDSRN

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CSRC - California Real Time Network (CRTN)
Proposed Backbone Network (163 Sites)

Caltrans Districts

CRTN backbone sites shown only. For all CRTN sites and additional information, please visit:

http://sopac.ucsd.edu/projects/realtime/

NOTE: All CRTN backbone sites were submitted to NGS on May 25, 2010 to be included into the NGS CORS network.
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
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

DELI VERED 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

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Differential Carrier Phase GPS and Magnetometer Combined

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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

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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.

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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)

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Mobile LASER Scanning (Reliant on GPS for Horizontal Control)

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LASER Scanning Example
Doyle Drive – San Francisco

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Laser Scanning Point Cloud

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Vertical Component Verification
(praecise level data used for vertical)

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## Comparison of Stationary Scan vs. Mobile Scan Vertical Data

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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

Geographic Information Systems (GIS)

Wards and Precincts
Demographics
Structures
Water Utilities
Sewerage
Electrical Utilities
Roads
Boundaries
Land Use
Hydrology
Soils
Topography

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QUESTIONS?

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