APPENDIX A – ADVANCED SURVEYING TRAINING SLIDES

Advanced Survey Technologies

Systems Overview & Applications

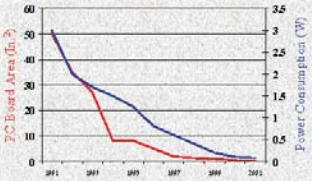
Presenters: Gregory A. Helmer
Alan Blair

RBF CONSULTING

Federal Highway Administration

1

GPS Technology Curve



1987 50 Lbs $50K

2

GPS Applications

Smaller, Faster, Lighter

Microwave Telemetry, Inc.
70 Grams
GPS & ARGOS

3

Spatial Data Demand

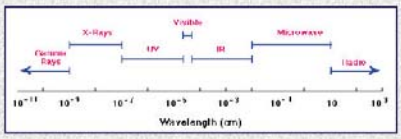
Increased:

- Demand for data.
- Processing capacity.
- Communications

- Capacity
- Applications
- Demand

4

Spectrum and Sensors



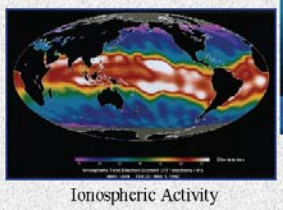
Instrumentation continues to detect ever finer units of a broader spectrum using less power and with increased accuracy.

2 x Capability & 0.5 x Cost in 18 Months
Moore's Law

5

Remote Sensing

- Atmosphere & Weather
- Ground Topography
- Human Activity



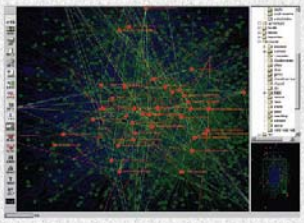
Ionospheric Activity

Shuttle Radar Topography Mission, Feb 2000

6

Communication and Data Distribution

"Twitch-Time"
Desktop Publishing
Fax
Cell Phone
Email
Web Portals
Desktop Mapping
Web Everywhere



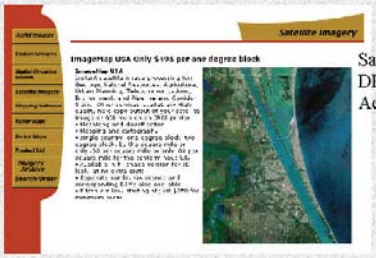
Topological Internet Map
http://www.cybergeography.org/

7

Net Meetings

- Real-Time Sharing Desktop
- Redline / White Board
- Remote Access
- Training

Commercial Data Products



Satellite Imagery
DEM
Aerial Photography

http://www.eomonline.com/

9

Satellite Imagery Sources

Satellite	Operator	Type	Resolution (m)	Revisit (days)
Landsat 5	Space Imaging	Multispectral	30	16
Landsat 7	US Government	Panchromatic	15	16
		Multispectral	30	
IRS	India	Panchromatic	6	5
		Multispectral	23	24
SPOT	CNES/SPOT	Panchromatic	10	4-Jan
		Multispectral	20	
RADARSAT	Canada	Radar	8-100	Mar-35
ERS	European Space Agency	Radar	30-50	Mar-35
JERS	Japan	Radar	15	Apr-45
IKONOS	Space Imaging	Panchromatic	1	5-Mar
		Multispectral	4	
OrbView	Orbimage	Panchromatic	1	3
		Multispectral	4	
Quickbird	EarthWatch	Panchromatic	1	4-Feb
		Multispectral	4	
SPIN 2	Russia	Panchromatic	10	8
		Panchromatic	2	

10

Stock Aerial Photography

- 0.5 – 1.0 Meter
- Visible Color
- Ortho Rectified
- Annual Updates
- ≅ $5K/County

http://www.airphotousa.com

11

Free Project Data

- BLM Land Records
- GCDB
- Township Files
- NAD27

http://www.lsi.blm.gov/

12

Free Mapping Data

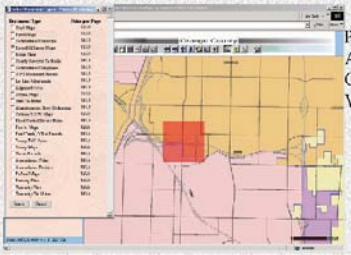
USGS: Digital Ortho Quads, Digital Line Graphs
FEMA Flood Maps
Census Bureau Demographics

NAD83
UTM Coordinates

http://terraserver.homeadvisor.msn.com/

13

E-Government



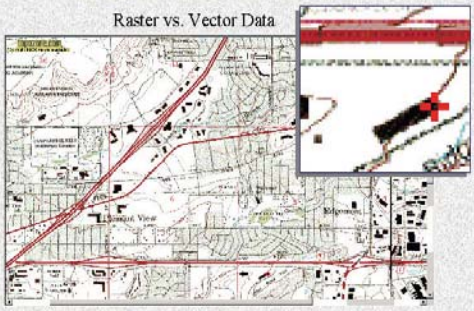
Permits
Applications
Community Services
Voting

Land Survey Records

14

Digital Raster Graphics

Raster vs. Vector Data



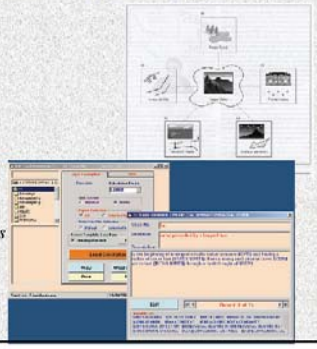
http://www.topozone.com/

15

Representation of Spatial Entities

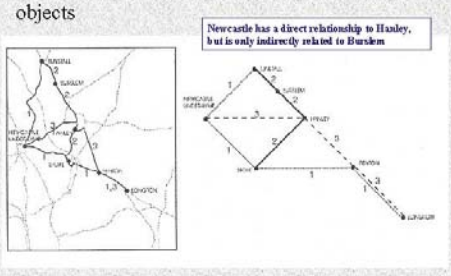
- Point
- Line
- Area
- *(Surface)*
- Data Tables

Legal Description Writers

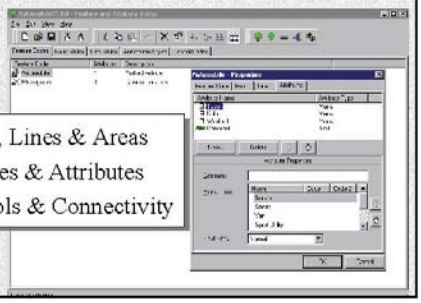


Topology

Topology is concerned with the logical relationships between the position of geometric objects



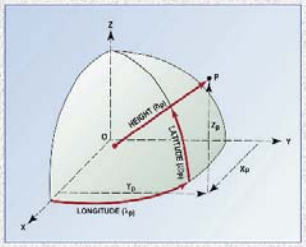
Data Dictionary



- Points, Lines & Areas
- Features & Attributes
- Symbols & Connectivity

Geodetic Datum

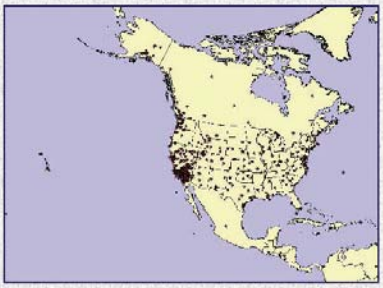
- Provides orientation and scale
- Mathematically defined



- NAD27
- NAD83
- ITRF97
- ITRF2000

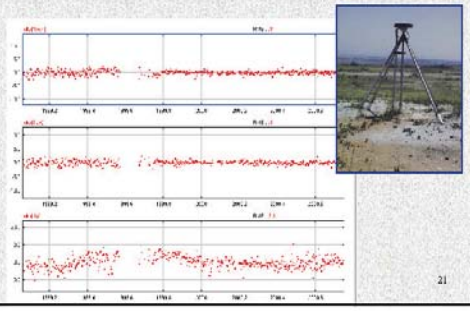
19

Existing North American CORS



20

CORS Observation Stability



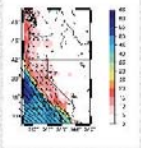
21

Online Data Processing

GPS CORS Processing

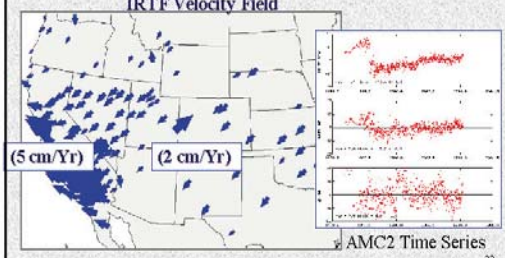
http://www.ngs.noaa.gov/TOOLS/

HTDP
Velocity Model
Datum Transformation



Datum Stability

IRTF Velocity Field



AMC2 Time Series

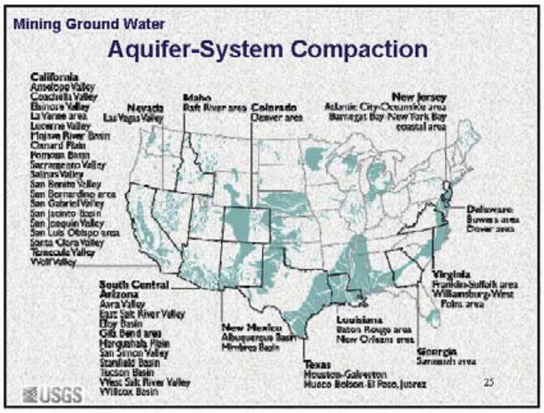
23

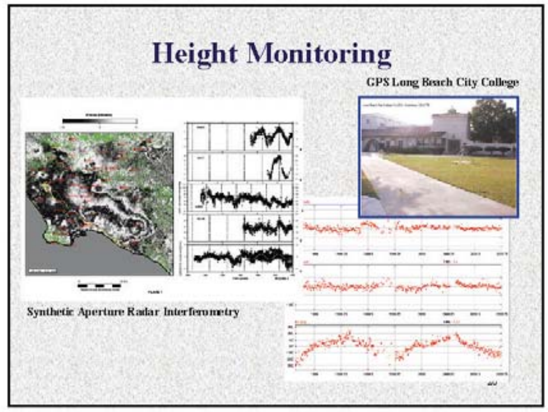
Vertical Deformation

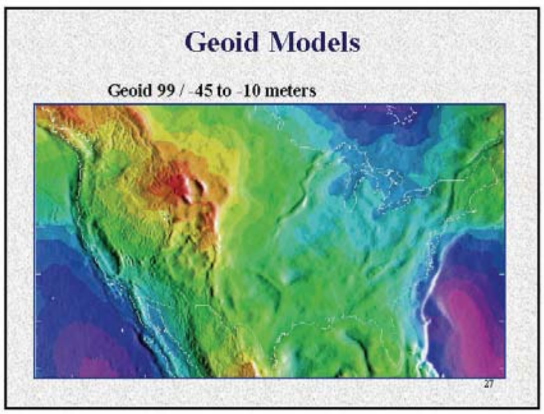
Subsidence / Uplift / Monuments and Structures

Hector Mine M 7.1 1999

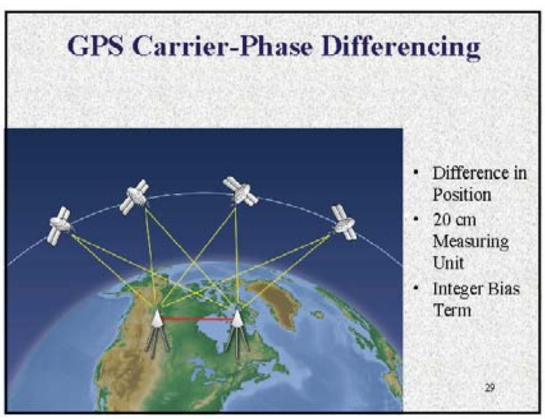
24

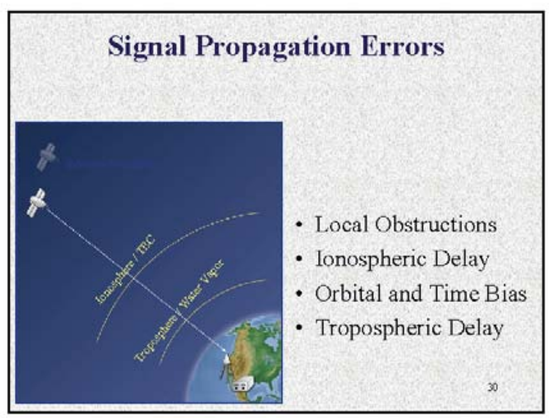

Mining Ground Water
Aquifer-System Compaction
California
Antelope Valley
Coachella Valley
La Verne area
Lucerne Valley
Mojave River Basin
Oxnard Plain
Pomona Basin
Sacramento Valley
Salinas Valley
San Benito Valley
San Bernardino area
San Gabriel Valley
San Jacinto Basin
San Joaquin Valley
San Luis Obispo area
Santa Clara Valley
Temecula Valley
Wolf Valley
Nevada
Las Vegas Valley
Idaho
Raft River area
Colorado
Denver area
New Jersey
Barnegat Bay-New York Bay
coastal area
Delaware
Dover area
Virginia
Franklin-Suffolk area
Williamsburg-West
Point area
South Central
Arizona
Avra Valley
East Salt River Valley
Eloy Basin
Gila Bend area
Harquahala Plain
San Simon Valley
Stanfield Basin
Tucson Basin
West Salt River Valley
Willcox Basin
New Mexico
Albuquerque Basin
Mimbres Basin
Louisiana
Baton Rouge area
New Orleans area
Georgia
Savannah area
Texas
Houston-Galveston
Hueco Bolson-El Paso, Juarez
25
USGS


Height Monitoring
GPS Long Beach City College
Synthetic Aperture Radar Interferometry


Geoid Models
Geoid 99 / -45 to -10 meters
27

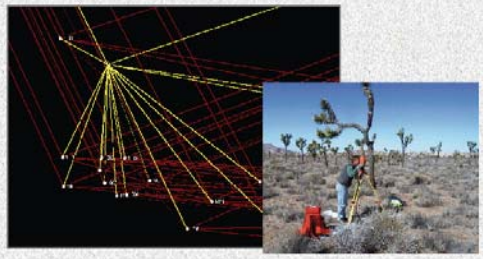

National Height Modernization
$12+ billion estimated value
• National terrain model
• Nationwide watersheds
• Special flood hazards
• Coastal erosion
• Maritime navigation
28


GPS Carrier-Phase Differencing
• Difference in Position
• 20 cm Measuring Unit
• Integer Bias Term
29

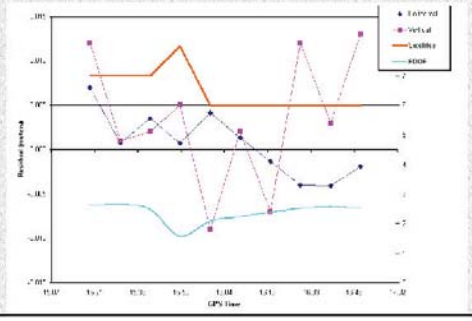

Signal Propagation Errors
Ionosphere / TEC
Troposphere / Water Vapor
• Local Obstructions
• Ionospheric Delay
• Orbital and Time Bias
• Tropospheric Delay
30

Project Control

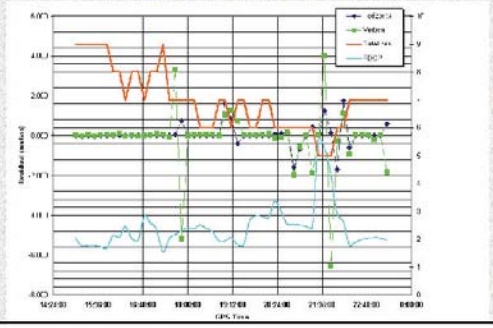
$500 - $1,500 Per Point
Accuracy / Quantity / Logistics



Kinematic Processing
1 KM Baseline



Kinematic Processing
10 KM Baseline



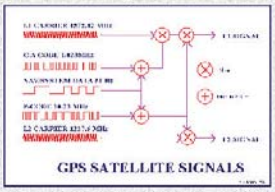
GPS Modernization

Operational 2007

- Third carrier frequency
- Additional civilian code

- Ambiguity Resolution
- Virtual Basestation Technology

1975 Signal Structure



34

The RDGPS Model

Real-time GPS provides efficient field inspection and analysis

Application-focused data collection brings specialized expertise to address investigations and timely field solutions.

35

Real-Time Reference Networks

Orange County Real-Time Network

Instantaneous Positioning

Virtual Reference Technology

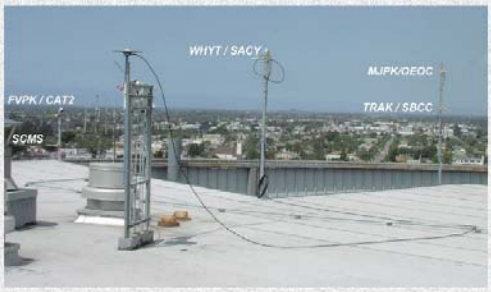
SCIGN Sites and OCRTN Baselines

- SCIGN deeply-anchored drill-braced monument at all sites except TRAK
- Ashtech Z-XII dual-frequency GPS receivers with Dorne-Margolin choke ring antennas
- Data rate was @ 30 seconds; Sites now streaming Ashtech MBEN format @ 1 second for OCRTN

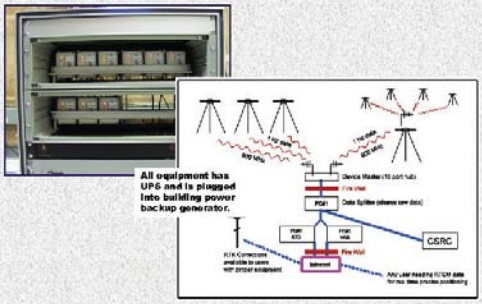
37

MJPK Repeater

Control Center Antennas



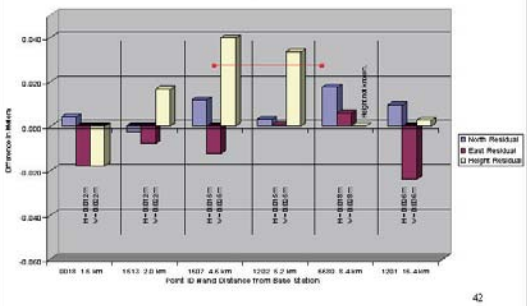
Network Data Topology



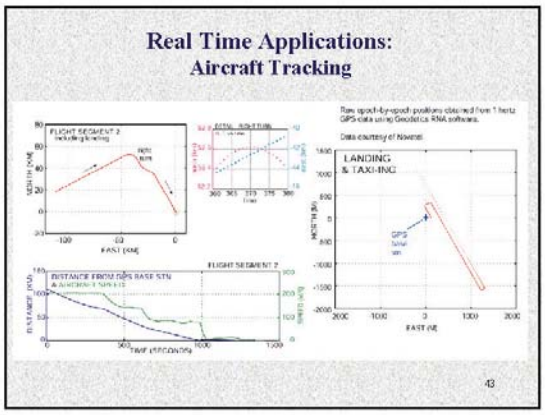
OCS - OCRTN – RTK Equipment

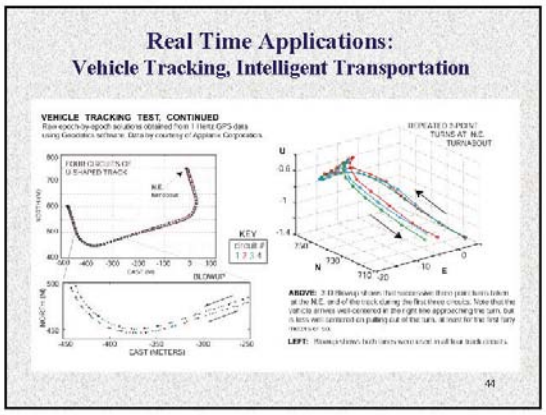
- Ashtech Z-Xtreme receiver
- Ashtech Geodetic-IV antenna
- TDS Ranger data collector
- Raven II CDPD modem
- 2-meter bi-pod
- Wireless Internet $65/Month

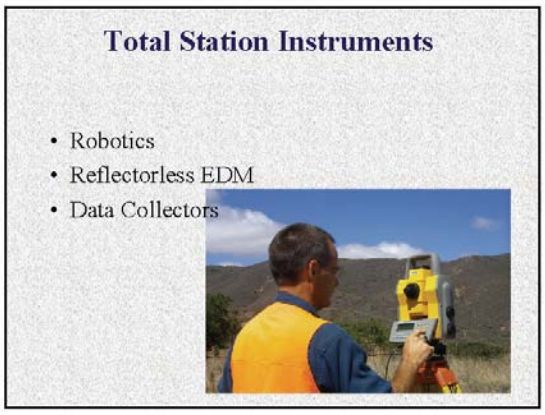
< 2 cm in < 2 minutes

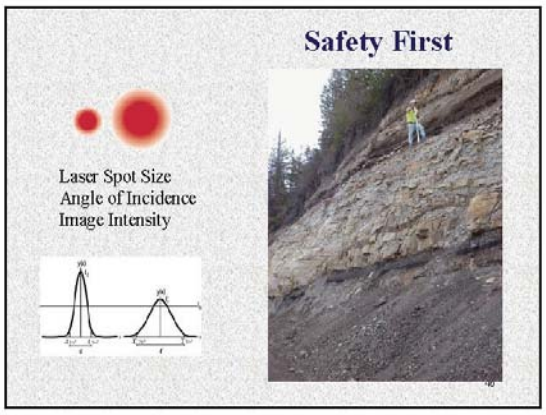


42

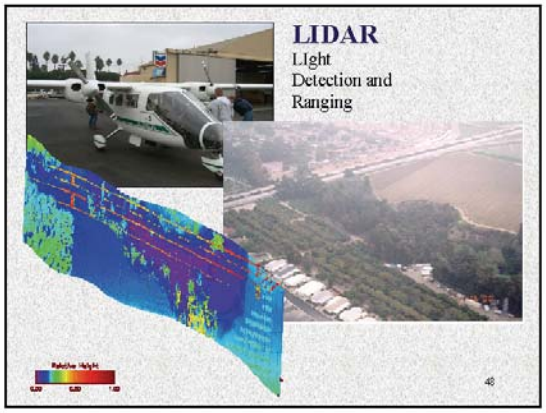

Real Time Applications:
Aircraft Tracking
LANDING
& TAXI-ING
43


Real Time Applications:
Vehicle Tracking, Intelligent Transportation
VEHICLE TRACKING TEST, CONTINUED
44

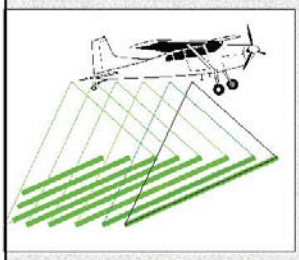

Total Station Instruments
• Robotics
• Reflectorless EDM
• Data Collectors


Safety First
Laser Spot Size
Angle of Incidence
Image Intensity


Laser Scanning Tests
cyrax


LIDAR
LIght
Detection and
Ranging
48

LiDAR Geometry



- GPS Position
- INS Attitude Yaw, Pitch, Roll
- Pulsed Laser
- Signal Return Time, Strength

49

LiDAR Helicopter Installation

Bell 206L Helicopter. Laser and Sensor are on the left and forward. Control and data acquisition computer is on the right and aft. (Aspen Helicopter Inc.)

View from below. Receiver and laser exit optics visible.

50

LiDAR Fixed Wing Installation

Transceiver installs in mid-body section of the Partenavia Explorer (Aspen Helicopter Inc.)

Test mirror used for field alignment shows transmit and receive optics

51

GPS Base Station Setup

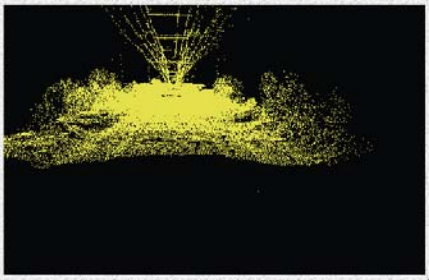
(Bell 206L Installation Shown)

52

Airborne Positioning

53

Data Point Overload

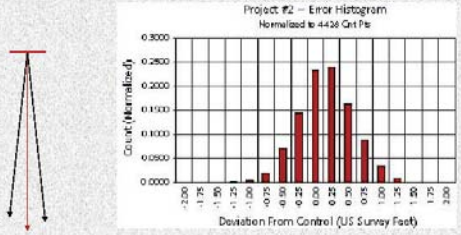


John Chance & Associates, Amtrak Corridor

54

LiDAR Accuracy Assessment

DTM 10 to 20 cm



Horizontal Weakness
0.005° angular error = 0.87' at 10,000 ft

55

Mapping of Power Lines/ Structures for Pacific Gas and Electric

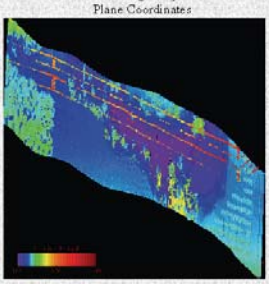
Power lines and structures are faintly visible in the aerial photographs with adjacent heavily wooded areas.

The 3D map shown on the next page has its upper left corner corresponding roughly to the upper left corner of the left image, where the tower structures can be seen adjacent to the divided roadway.

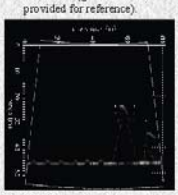
56

Mapping of Power Lines/Structures for Pacific Gas and Electric (PG&E)

Pseudo-Color Range Map in Cal State Plane Coordinates



Single 2D STIL Image (one laser pulse) From Map Data Set at Left (grid in meters provided for reference).



Though the cables are under-resolved, they are readily detected and clearly visible, though the upper lines dominate the map data shown at the left. The 2D image shown above shows the full set of wires on the tower structure, with its group of triangles at bottom

57

Third-Generation STIL LiDAR Sensor

Under ONR funding, a dual receiver STIL system has been integrated into a 15" x 17" Towed Vehicle Section (tested early 2000)

58

IFSAR
Interferometric Synthetic Aperture Radar

- Two X-band radar antenna mounted in a LearJet 36A (or Satellite)
- Utilizes post-processed differential GPS and laser-based inertial measurement unit
- Flown at 12 Km acquires 10 Km swath
- Designed to collect <1meter accuracy DEM at a rate of 100Km^2 per minute

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Interferometric Synthetic Aperture Radar IFSAR – Light Detection and Ranging Comparrison

Parameters	IFSAR	LiDAR
Sensor Type	Radar	Laser
DEM Spacing	5-10 Meters	0.5 –3 Meters
Vertical Accuracy	0.6 – 1.5 meters	6cm and up
Typical Cost	$11 - $80 Km^2	$225 - $1,500 Km^2

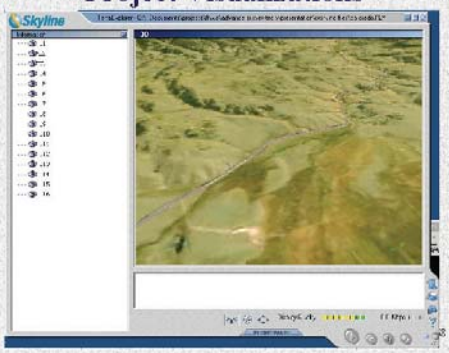
60

Machine Guidance Systems

- Construction Equipment
- Intelligent Vehicles
- Precision Navigation
- Aircraft Landing

67

Project Visualizations



Project Visualizations

69

Advanced Technologies

Benefit or Burden?

70