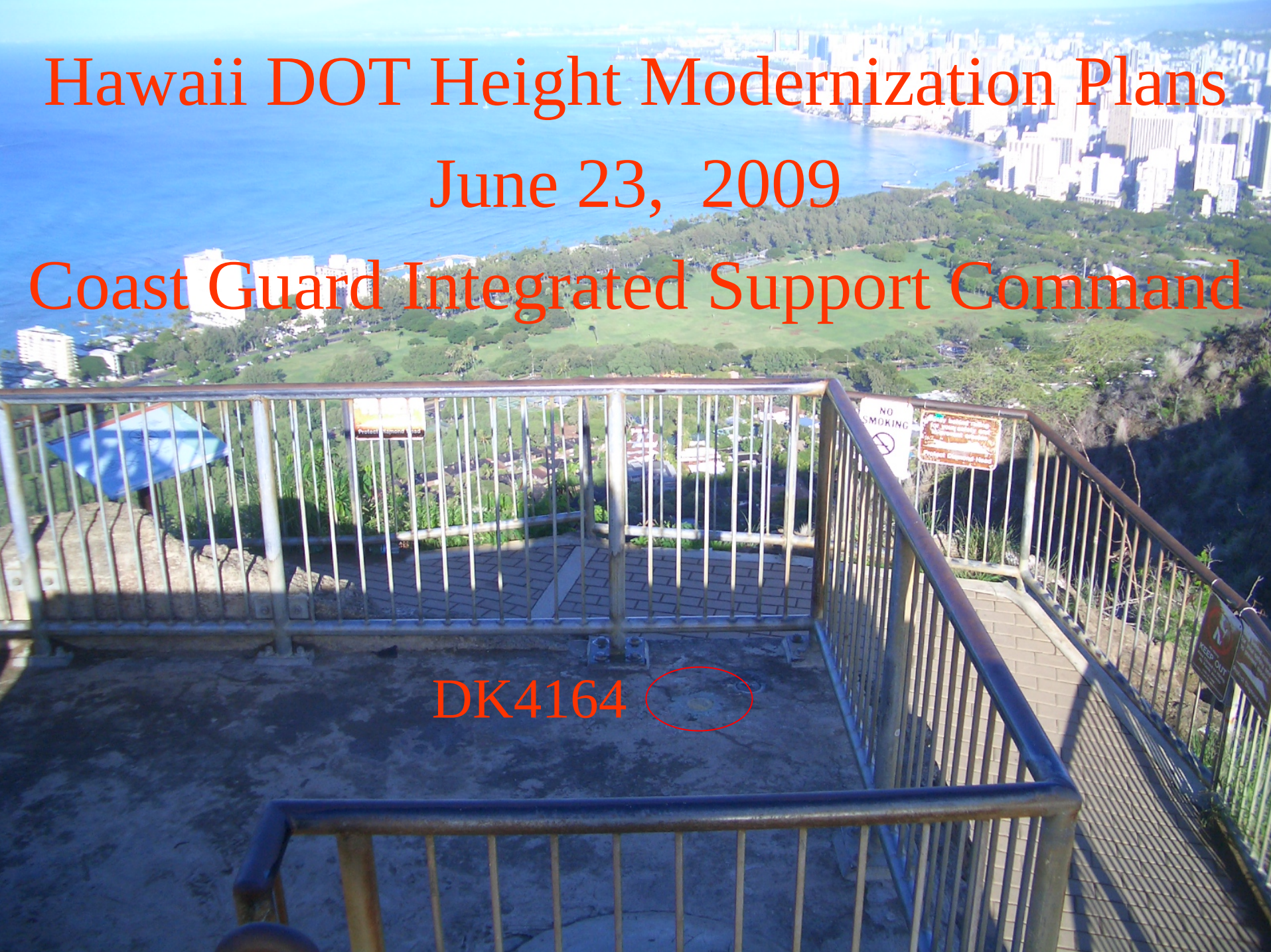
Hawaii DOT Height Modernization Plans

June 23, 2009

Coast Guard Integrated Support Command



Purpose of the Height Modernization in Hawaii

- The purpose of the Height Modernization in Hawaii is because we have not updated our benchmarks since the 70's. A good portion of the benchmarks were lost due to construction, vandalism and highway widening, etc…
- After looking at vertical issues, we proceeded to look at the horizontal controls and decided there is a need to be updated. Comparing with what the other states are doing to address this same issues, we decided to do a Height Modernization project with some additional activities to make the most of it.

Who will Benefit MOST?

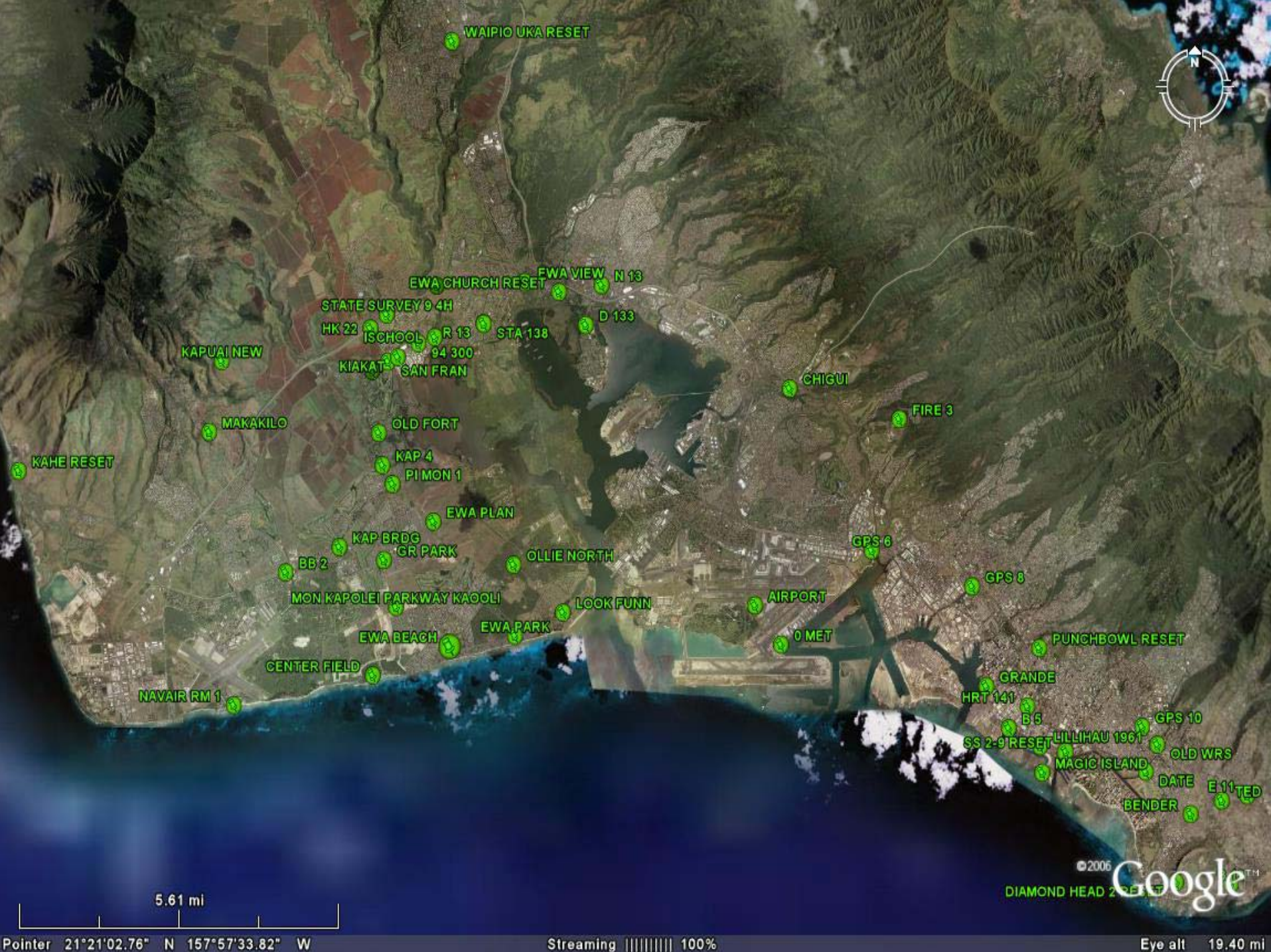
- Private Sector (Engineers, Surveyors, Planners, Contractors, and Construction Company's, etc.)
- Government Sector (Military, Federal, State, County)
- Public Utilities - Precision As-builts
- GIS Community
- And the **tax payers** in general (lower cost for surveying, engineering, etc.)

Benchmark Recovery

- Cadastral Engineering Section has completed the benchmark recovery for Oahu. Field work only.
- A total of 341 benchmarks was searched for
- 197 benchmarks recovered
- 144 benchmarks destroyed, damaged or could not be found.

HARN Projects Completed

- 3 HARN projects completed
  - 2004 HARN (Demonstration Project)
    - 4 “A” Order station installed
    - 7 Station upgraded from 1st Order to “A”
    - 2 existing benchmarks have now 1st order horizontal positions
      - Area Covered Kahe to Kaimuki
  - 2006 HARN (User Densification Project)
    - 23 Station added in this project
      - Areas covered Ewa Beach and Waipahu
  - 2008 HARN
    - 10 New “B” order station added
    - 3 existing benchmarks have now “B” order
      - Areas covered Downtown to Diamond Head



Pointer 21°21'02.76" N 157°57'33.82" W Streaming 100% Eye alt 19.40 mi

Plans for Hawaii DOT Height Modernization

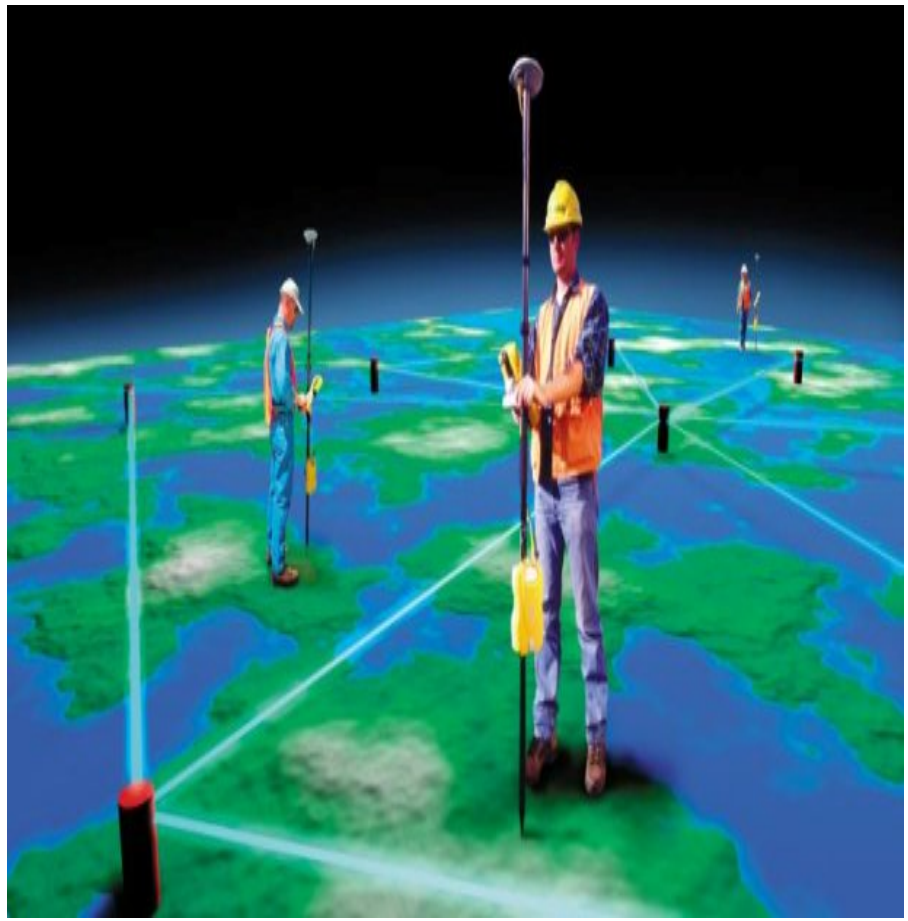
- Phase 1 – CORS / VRS (Begin in FY 10 and 11)
- Phase 2 – Digital Leveling (Begin in FY 10 and 11)
- Phase 3 – LIDAR (FUTURE)
- Phase 4 - Research and Development (FUTURE)
- Phase 5 - Reference Center (FUTURE)
- Phase 6 - Outreach and Training (FUTURE)

Phase 1 CORS and VRS Plans

- Oahu - 7 CORS Stations
- Maui - 8 CORS Stations with a possible 9th station
- Kauai – 6 CORS Stations
- Big Island – 9 CORS Stations

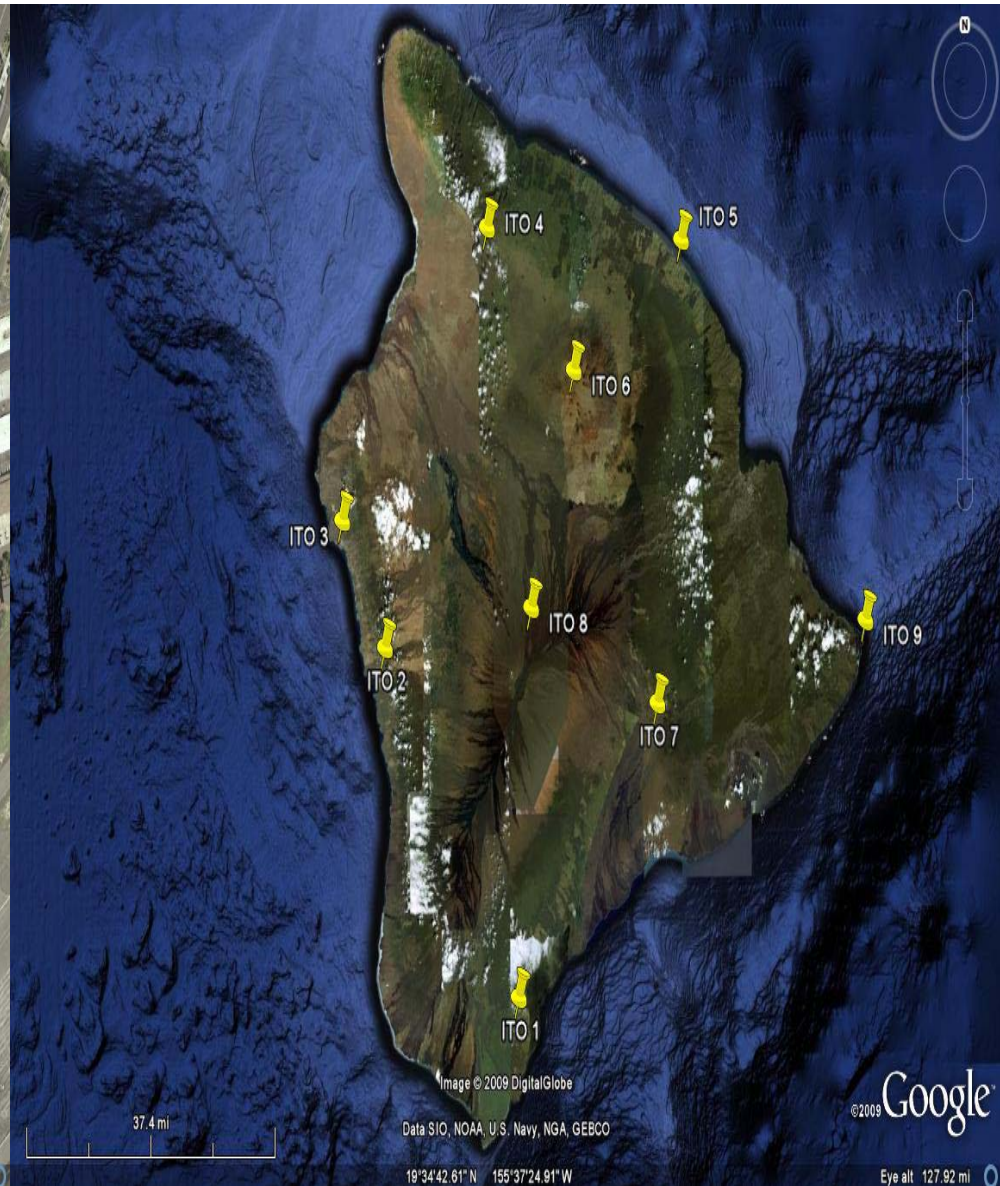
What is VRS (Virtual Reference Station)

- **Real time centimeter measurements within the island-wide or state-wide network without setting up a base station**

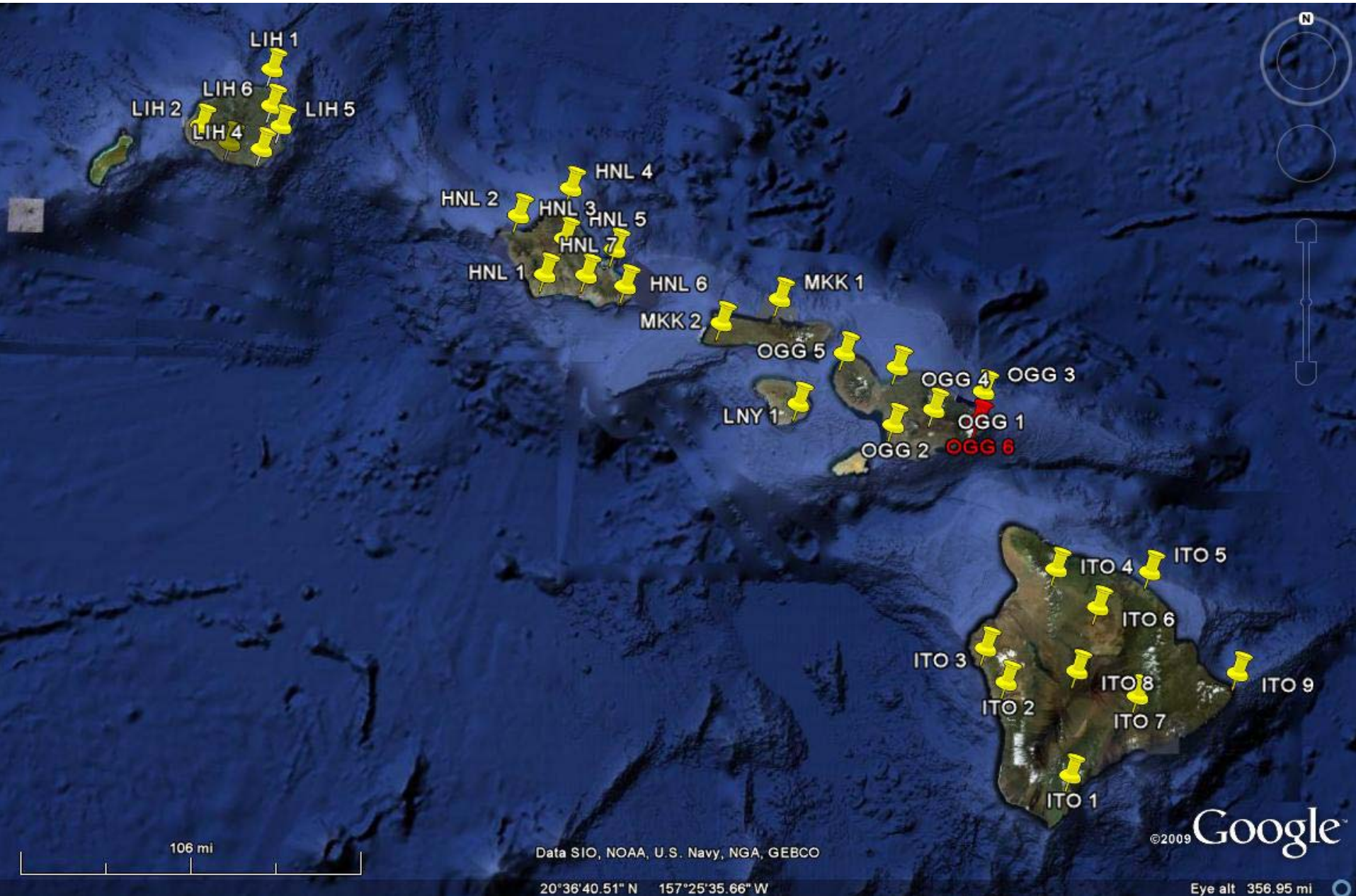


- GPS Receivers:
  - Current GNSS Receivers and Geodetic Antennas
- Equipment:
  - Solar panels, backup batteries, battery enclosure box
  - Modem radio where no internet exist to provide a single base solution
- Construction:
  - In Federal, State or County property where possible
  - Sites may change depending on site issues (high buildings, trees, transmission towers, mountains, etc.)
- Servers
  - Central server with redundant server located in each county.

Scaleable from a small single network to a island wide



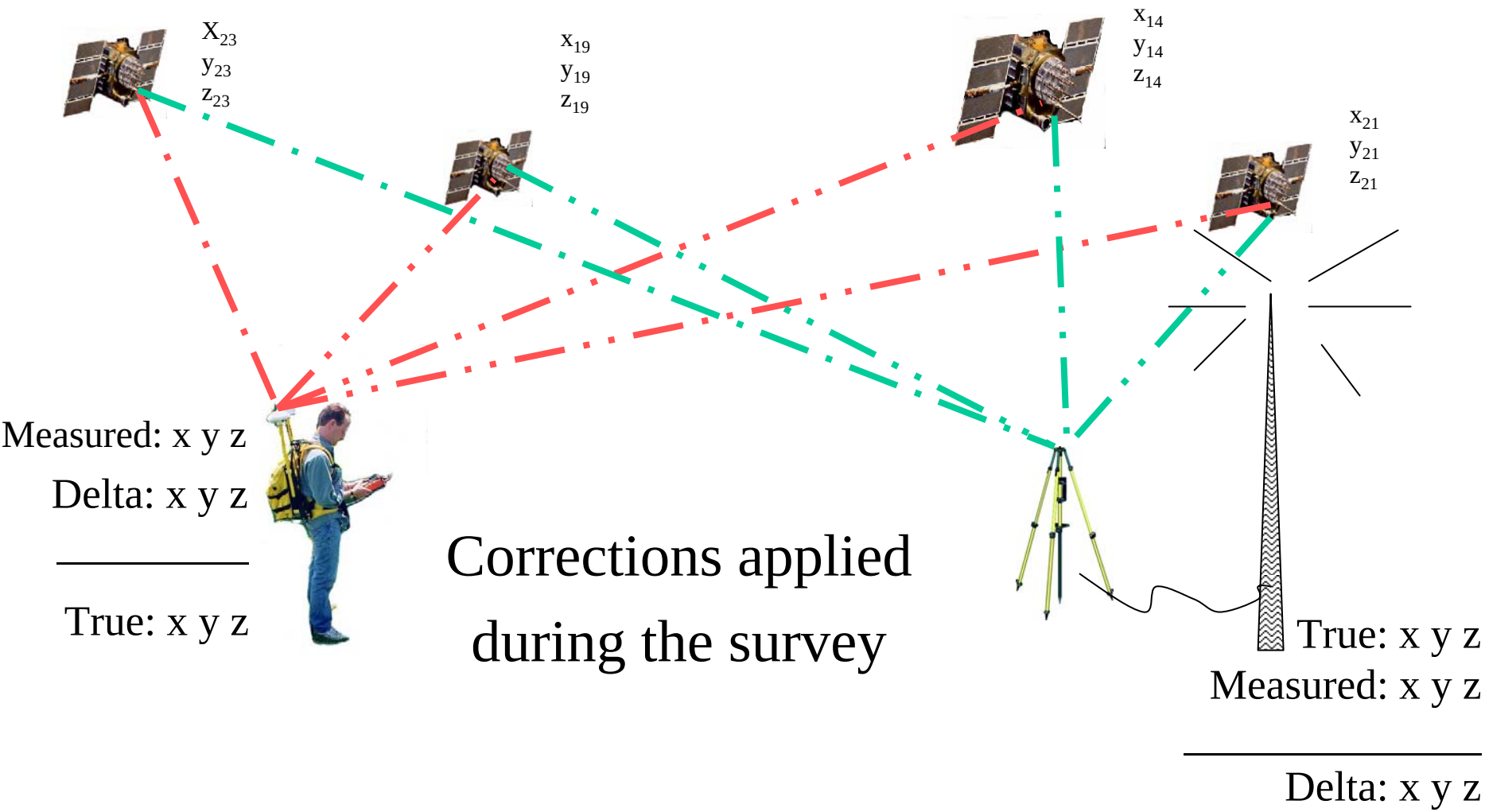
to a State Wide Network



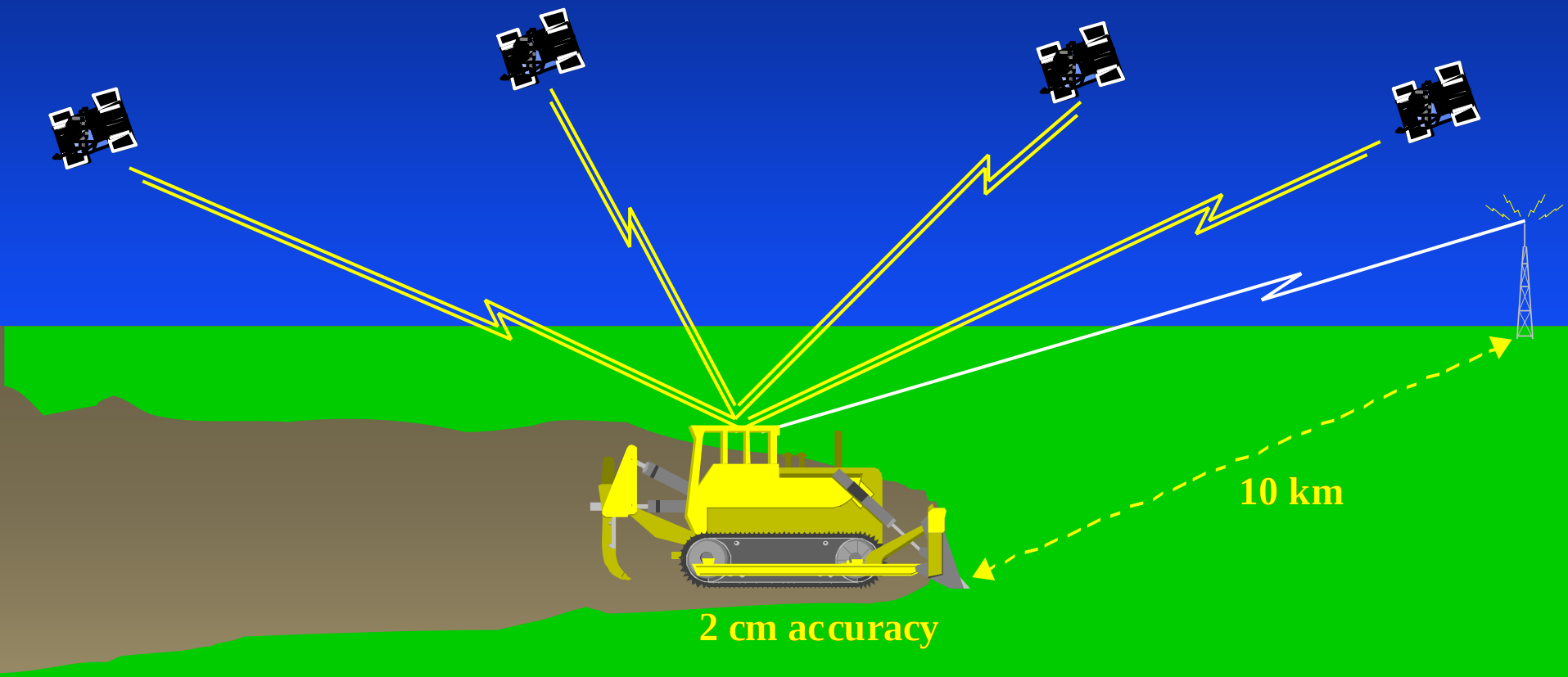
A Good Money Saver

- There is no need for buying a base station
- There is no need to leave a person to watch the base station
- The VRS System will allow user to complete lager project faster with less cost

Real-Time Differential GPS

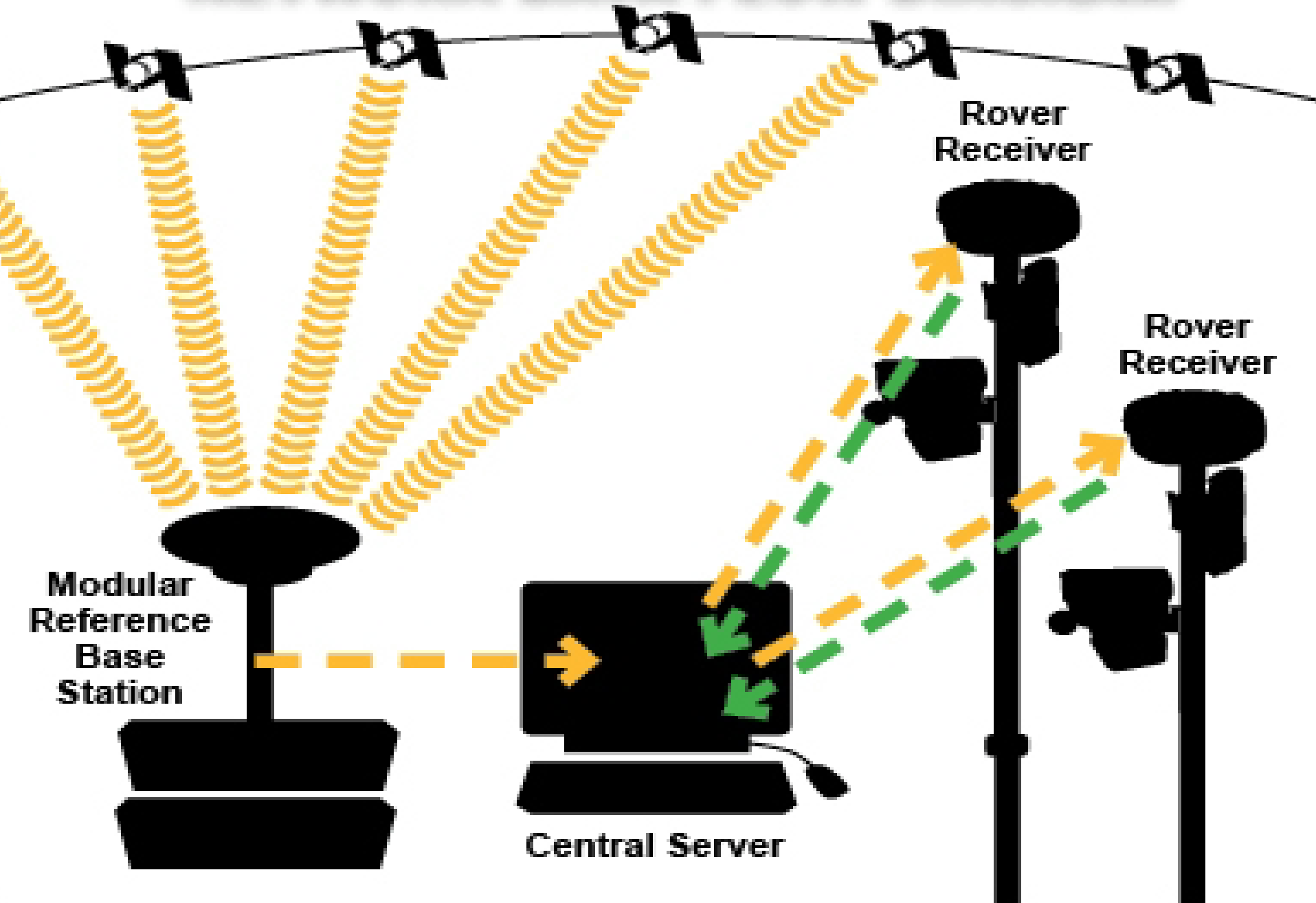


Real-Time Kinematic: Today



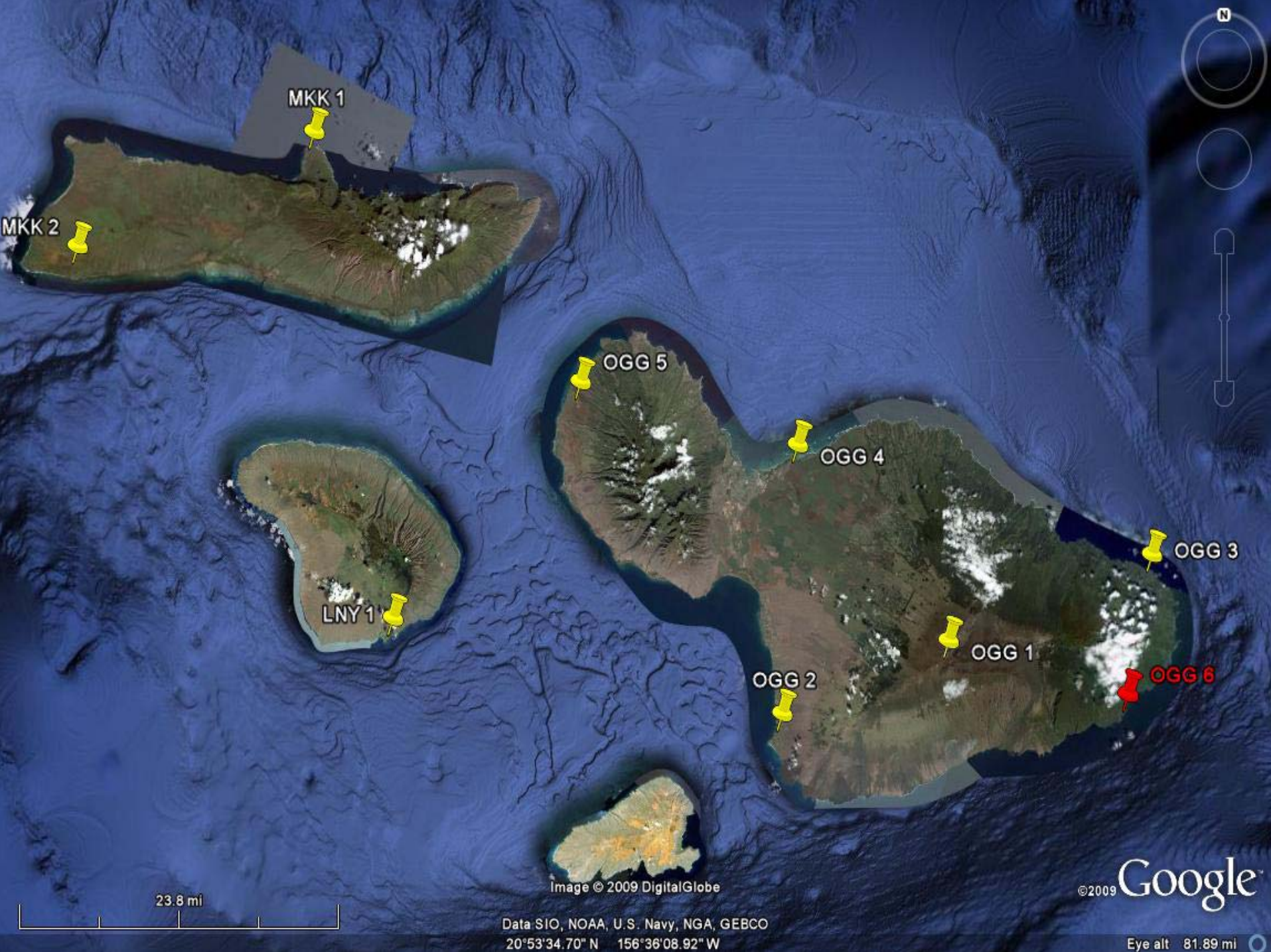
- L1 Code and Carrier
- L2 Carrier
- Data Link

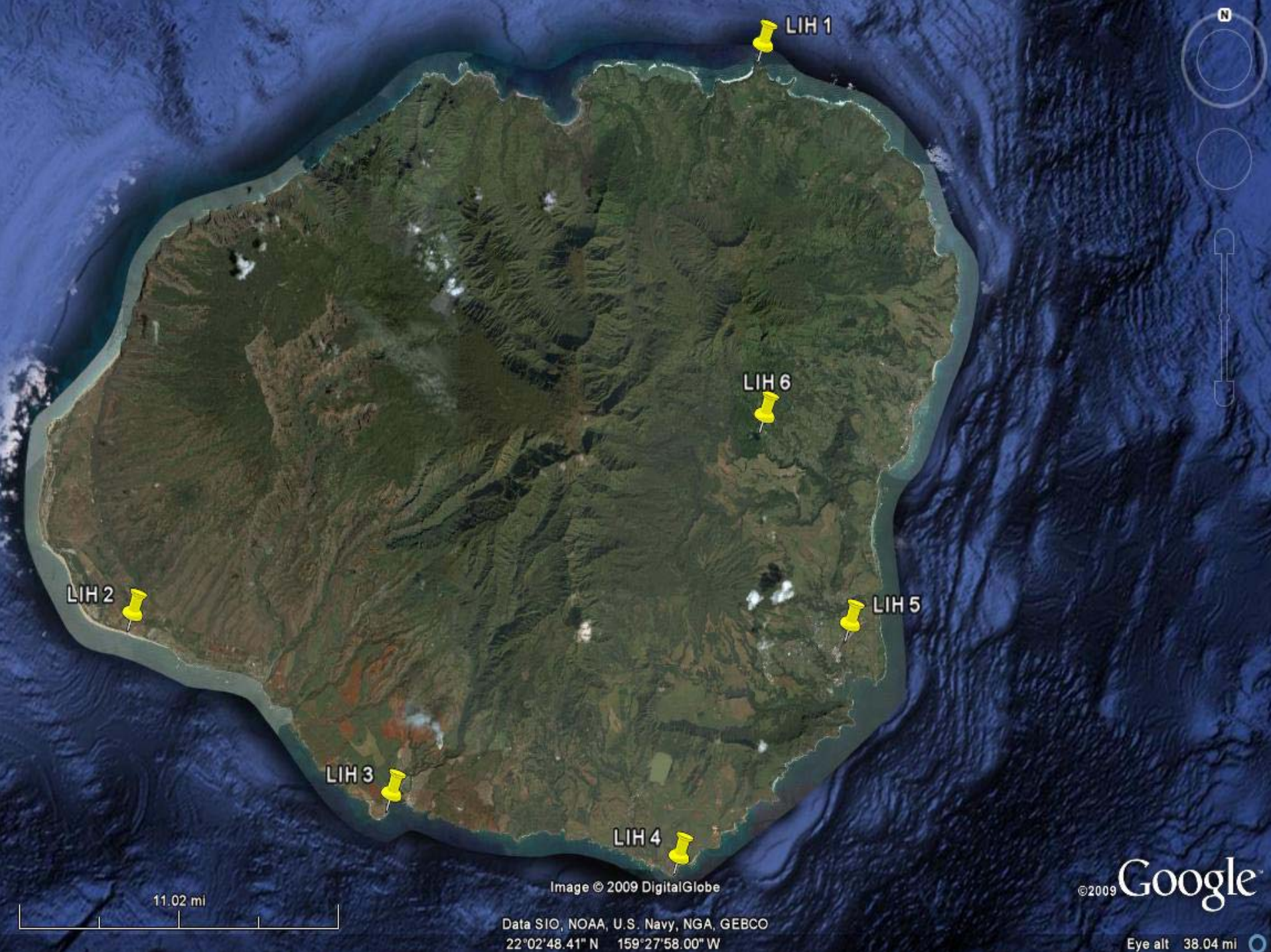
NETWORK DATA FLOW DIAGRAM

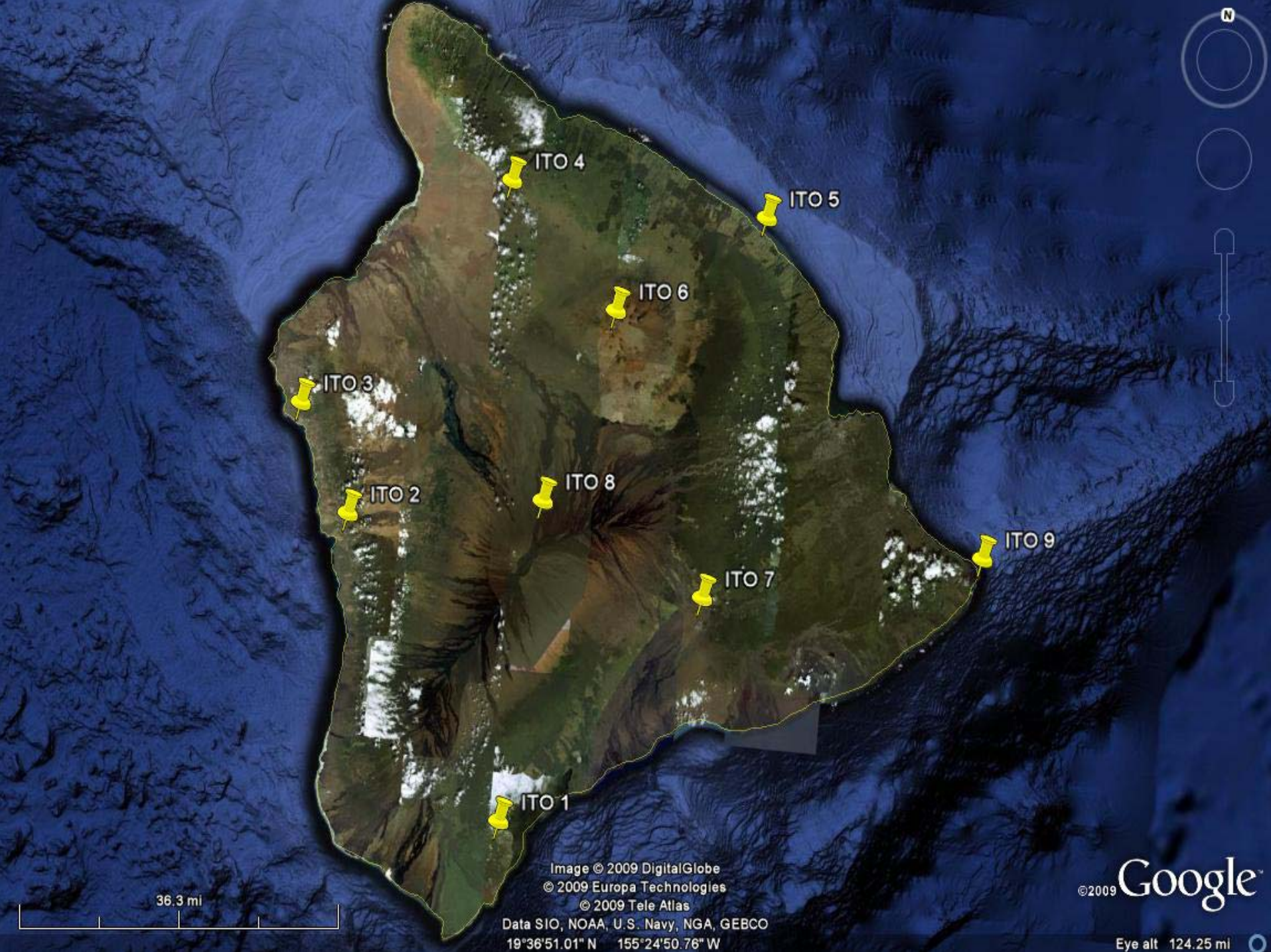



CATERPILLAR

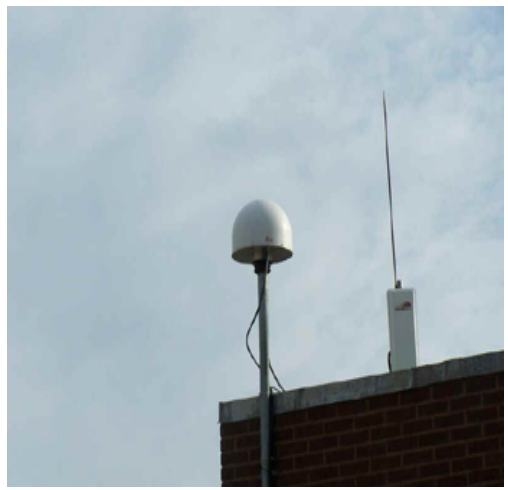

HNL 4
HNL 2
HNL 3
HNL 5
H2
H3
H1
HNL 1
HNL 7
HNL 6
Image U.S. Geological Survey
Image © 2009 DigitalGlobe
© 2009 Tele Atlas
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
21°29'35.06" N 157°55'48.05" W
12.90 mi
©2009 Google
Eye alt 44.51 mi


MKK 1
MKK 2
OGG 5
OGG 4
OGG 3
LNY 1
OGG 1
OGG 2
OGG 6
Image © 2009 DigitalGlobe
©2009 Google
23.8 mi
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
20°53'34.70" N 156°36'08.92" W
Eye alt 81.89 mi


LIH 1
LIH 2
LIH 3
LIH 4
LIH 5
LIH 6
N
Image © 2009 DigitalGlobe
©2009 Google
11.02 mi
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
22°02'48.41" N 159°27'58.00" W
Eye alt 38.04 mi


ITO 4
ITO 5
ITO 6
ITO 3
ITO 2
ITO 8
ITO 9
ITO 7
ITO 1
36.3 mi
Image © 2009 DigitalGlobe
© 2009 Europa Technologies
© 2009 Tele Atlas
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
19°36'51.01" N 155°24'50.76" W
©2009 Google
Eye alt 124.25 mi

Example of CORS stations



CORS / VRS ADVANTAGES

- 3-dimensional.
- Users do not need to reconn control points.
- Users do not need to set up instruments at control points.
- CORS positional coordinates are more accurate than those of other control points.
- Direct tie to National Spatial Reference System.
- CORS positions and velocities are available in both NAD 83 and ITRF coordinate systems.
- CORS positions are continuously monitored and will be updated if the site moves.

Phase 2 Digital Leveling

- Order of Survey
  - Second order or better
  - Starting at a tidal station
- Digital Level ONLY
  - **ONLY** digital level will be accepted
  - First order instruments will be used
  - Thermister – Upper and Lower will be used
  - Collimation Check must be completed daily
- Invar Rods
  - Single piece, barcode, calibrated rod with brace poles
- Turtle or Turning Pin
  - weighing at least 7 kg

Digital levels

Thermister


Digital Temperature Readout for Top and Bottom Temperature Probes
Accurate to 1.0 Degree Celsius
Fixed Leg Tripod - Single-piece, un-adjustable legs
Aspirated Temperature Probes - Consist of Concentric Cylinders, Fans, and a Thermister
Located at 30 cm and 130 cm on the Tripod
Battery Supply for the Fans on the Temperature Probes

Single-Piece, Bar-Coded Invar, Calibrated Rod with Brace Poles

Turning Plate “Turtle”

Turning Pin Setup – Cap Off

Level Unit One Observer
Two Rod Persons

Typical Level Unit

- One observer (instrument person)*
- Two rod people*
- One or two vehicles
  - One capable of transporting equipment – rods*
  - Drop one vehicle at end of day's work
- Safety people if necessary
  - Warning person to drive behind crew
- One pacer to help with setups **
- Computer to download and process data*

* Required

** Optional

Estimated miles of leveling

- Oahu
  - Estimate of 211 miles
- Maui
  - Estimate of 251 miles
- Kauai
  - Estimate of 128 miles
- Big Island
  - Estimate of 410 miles


N
H1
H2
H3
93
12.08 mi
Image U.S. Geological Survey
Image © 2009 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2009 Tele Atlas
21°28'55.20" N 157°56'40.24" W
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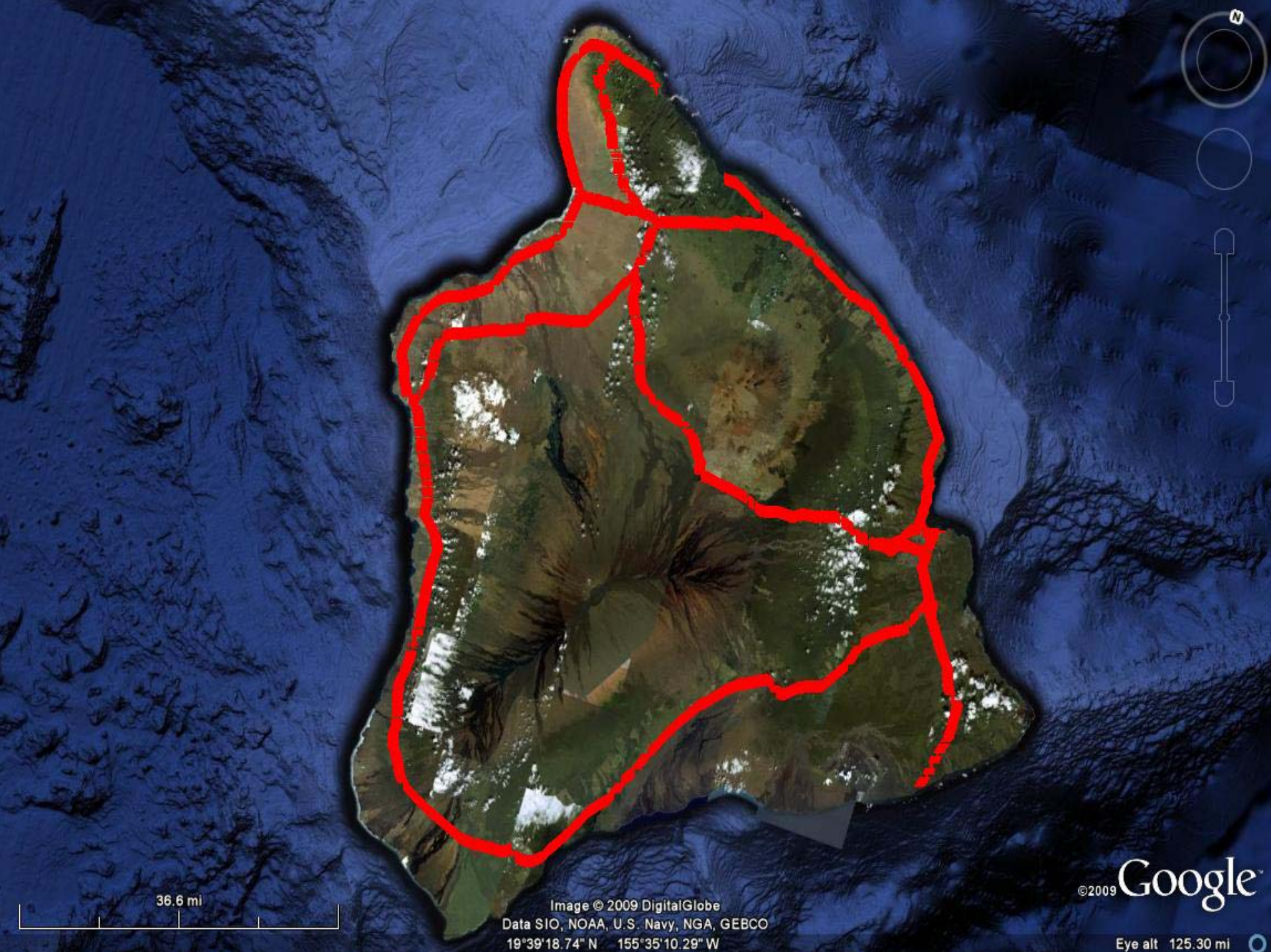
Eye alt 41.72 mi


N
13.16 mi
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2009 DigitalGlobe
©2009 Google
20°46'56.74" N 156°20'10.61" W
Eye alt 45.42 mi


N
9.52 mi
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2009 DigitalGlobe
© 2009 Tele Atlas
©2009 Google
21°09'48.86" N 157°00'28.31" W
Eye alt 32.92 mi


N
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2009 DigitalGlobe
Image © 2009 TerraMetrics
©2009 Google
5.57 mi
20°49'35.51" N 156°54'29.20" W
Eye alt 19.28 mi


N
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2009 DigitalGlobe
©2009 Google
9.91 mi
22°02'39.63" N 159°31'23.50" W
Eye alt 34.24 mi


36.6 mi
Image © 2009 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
19°39'18.74" N 155°35'10.29" W
©2009 Google
Eye alt 125.30 mi

VERTICAL ACCURACY STANDARDS

Relative Accuracy Between Directly Connected Points or Benchmarks

Classification	(Standard Error)
First, Class I	0.5 mm $\sqrt{K}$
First, Class II	0.7 mm $\sqrt{K}$
Second, Class I	1.0 mm $\sqrt{K}$
Second, Class II	1.3 mm $\sqrt{K}$
Third, Class I	2.0 mm $\sqrt{K}$

K = distance in Kilometers between points

Funding Phase 1 and 2

- Item Capital
- No. Project No. Title

- 138. X238 HEIGHT MODERNIZATION FACILITIES, STATEWIDE
-
- PLANS, LAND ACQUISITION, DIGN, CONSTRUCTION, AND EQUIPMENT FOR HEIGHT MODERNIZATION FACILITIES ON VARIOUS ISLANDS.

		Fiscal Year 2009-2010	Fiscal Year 2010-2011
PLANS		1	1
LAND		1	1
DESIGN		1	1
CONSTRUCTION		3,397	
EQUIPMENT			2,297
TOTAL FUNDING	TRN	3,399 E	2,299 E
	TRN	1 N	1 N

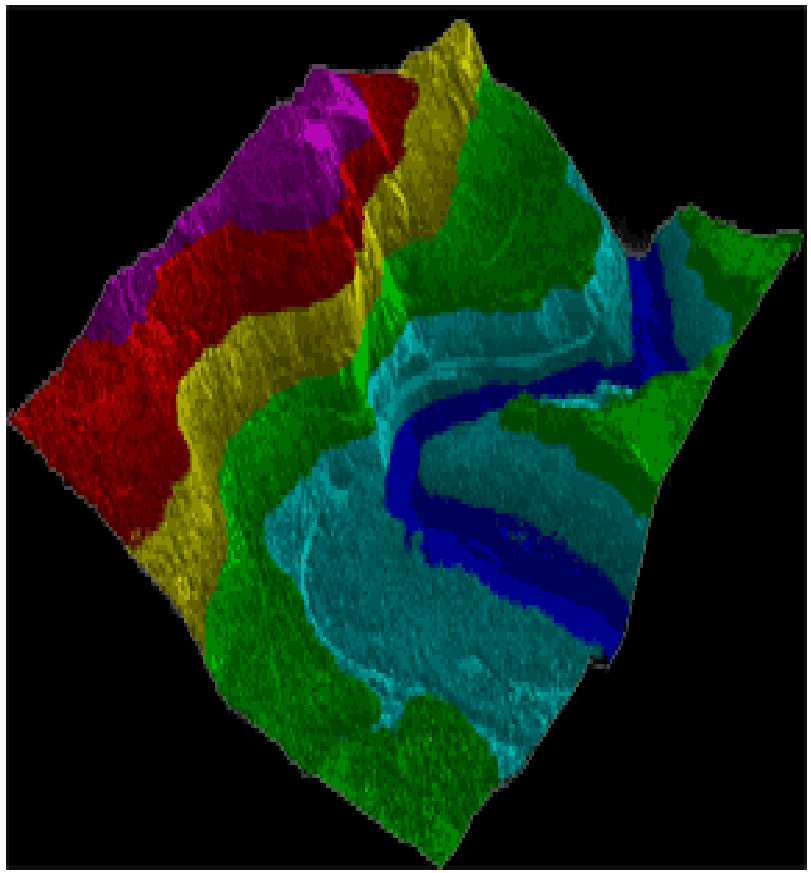
- About 5.7M

Future Funding Phase 3

- Future Funding will go through CIP same as Phase 1 and 2
- 5.6 M for LIDAR
  - Planning route
  - Plane & Fuel
  - Personal office and field
  - Processing and quality control check
  - Delivering data

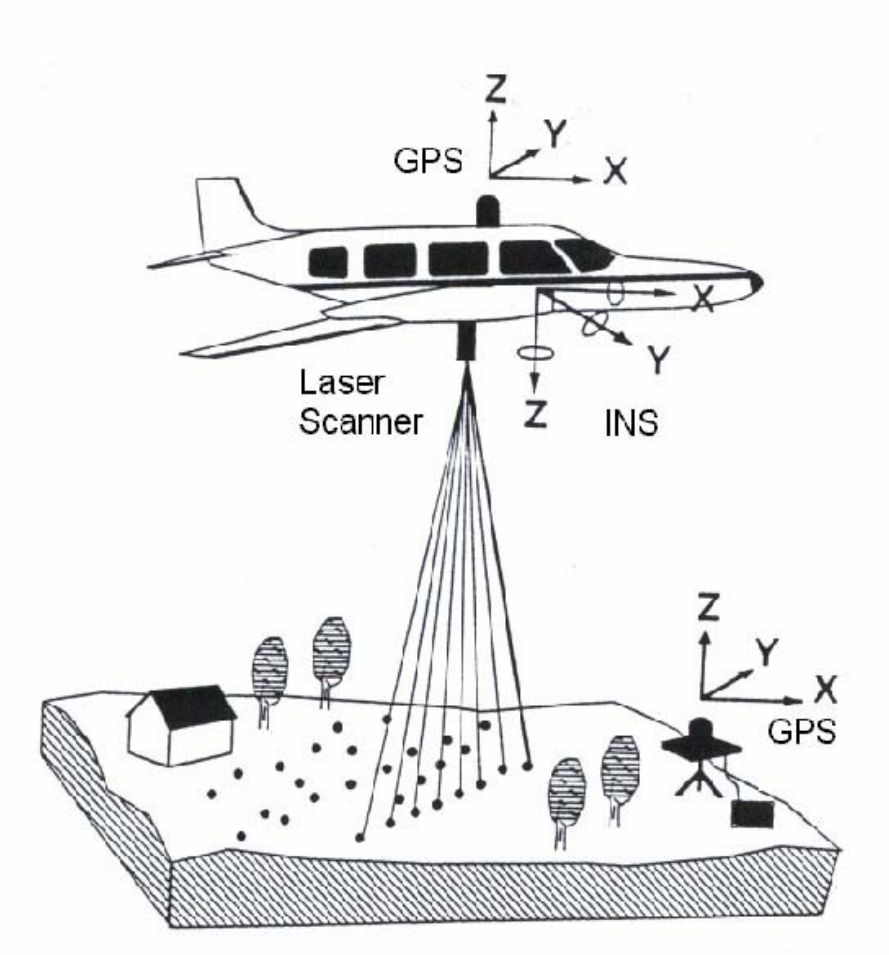
LIDAR (Light Detection and Ranging)

- Help to create a more accurate DEM (Digital Elevation Model) for the Hawaiian Islands.
- Help to create a more accurate Geoid Model for Hawaii.

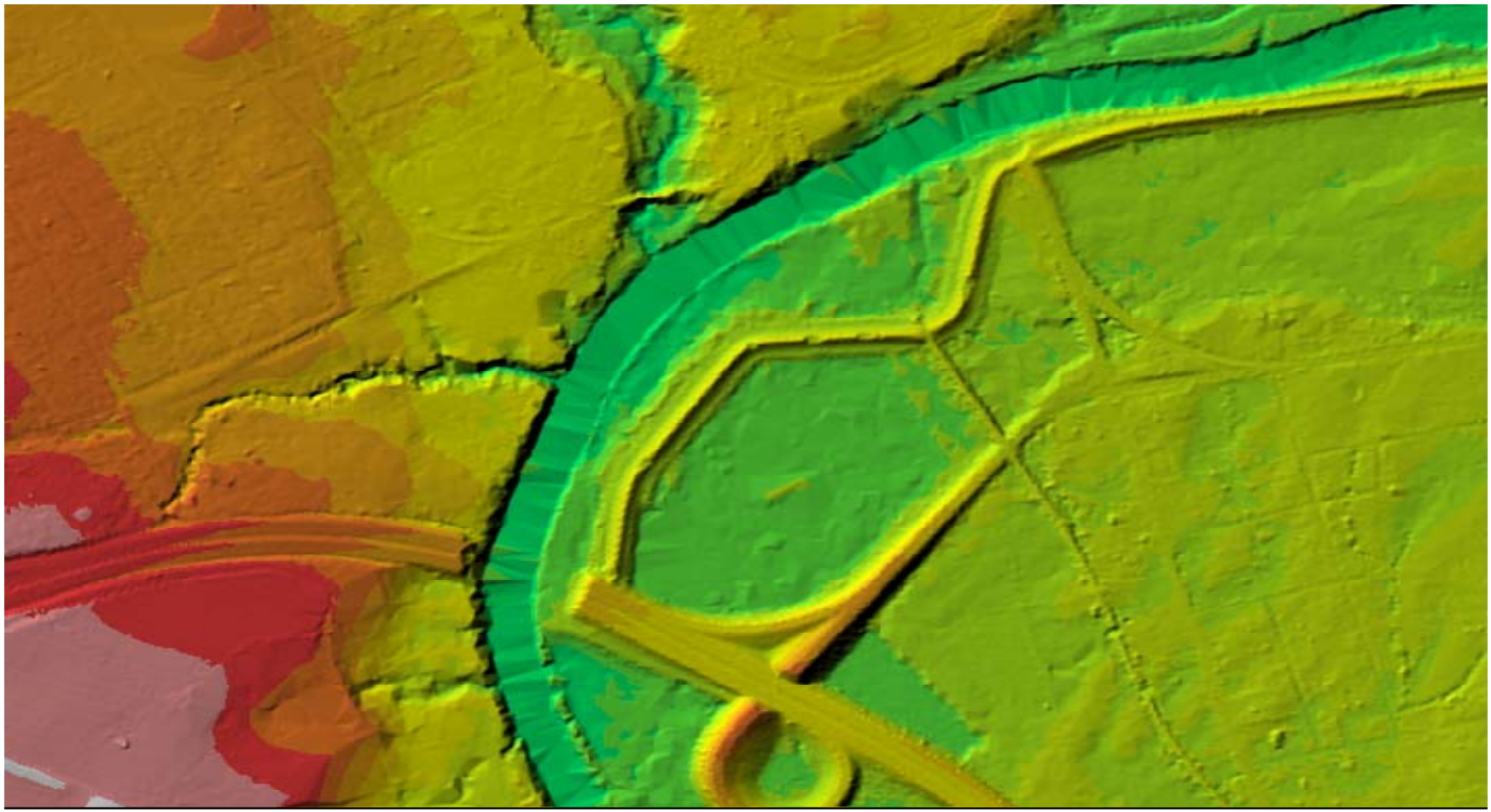


Example of LIDAR

- LIDAR is flown with a airplane or a helicopter
- A Laser scanner is shot from the plane to the ground feature, the return signal will create X,Y and Z for the ground features.
- Large amount data is collected in a very short amount of time.
- Shoreline Mapping
- Good for vary large areas



Digital Elevation Model (DEM)



Sample Bare Earth DEM
(Tarboro, NC)

Future Phase 3
Airborne Gravity Funding

- 1.3 M for Airborne Gravity
  - No Airborne gravity has been flown before in Hawaii
  - Providing single vertical datum consistent island-to-island
  - Area of approximate coverage 687,000 Sq km
- Figures from NGS “The GRAV-D Project” Report Nov. 14, 2007

Future Phase 4 - Research and Development and Future Phase 5 - Reference Center

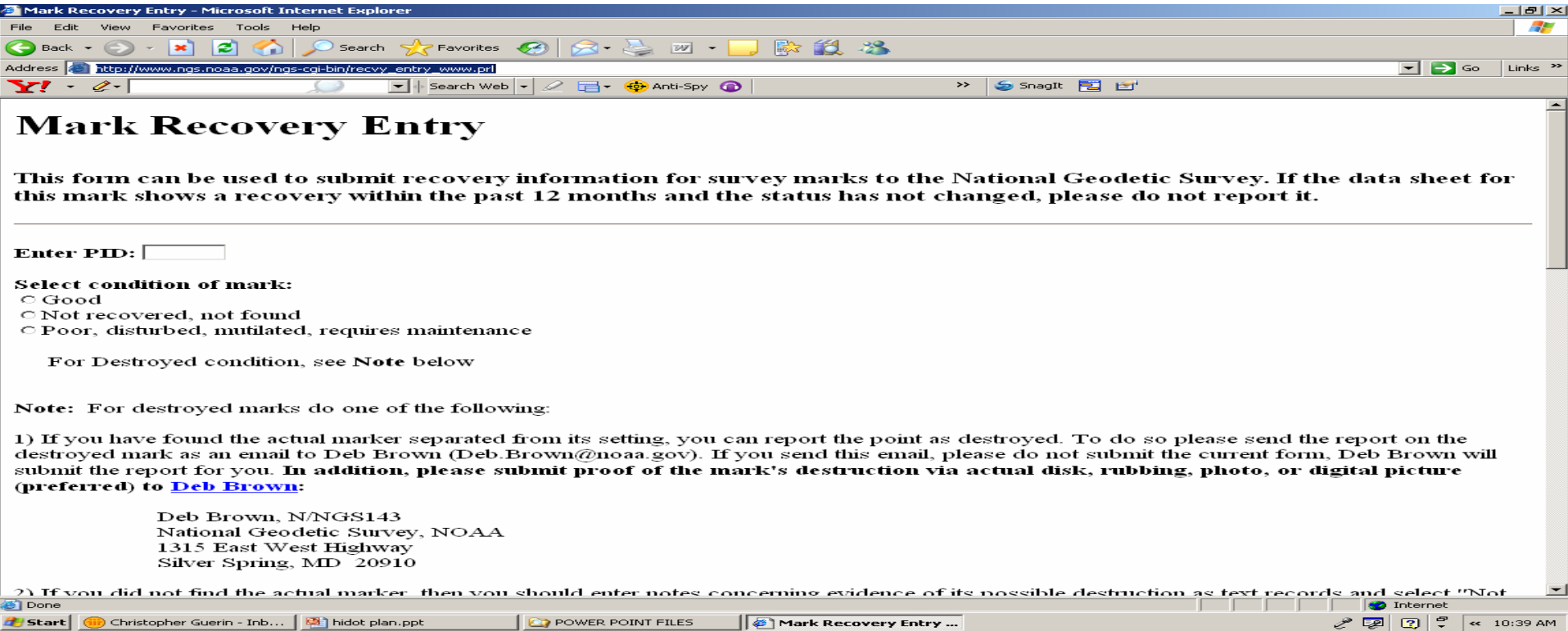
- Calculating of a new Geoid Model for the State of Hawaii
- Using the LIDAR Data and Airborne Gravity for the new Geoid Model.
- A major University to make calculation
- NGS to advise when needed.
- New Geoid Model to be published and used for Hawaii
- LIDAR and Gravity Data to be stored and shared as needed.
- Data center for VRS/ CORS data.

Phase 6 - Outreach and Training (FUTURE)

- **GPS, leveling, CORS/VRS Training Workshop:** are future workshops designed for government agencies, professional surveyors and engineers and the GIS community.
- Workshops are tailored to each group's respective needs

How can you help

- Mark Recover Program
  - http://www.ngs.noaa.gov/ngs-cgi-bin/recvy_entry_www.prl
  - You can report your finds to the NGS website if you find a Vertical or Horizontal disk out in the field.



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  808-692-7608 Fax

  christopher.guerin@hawaii.gov

Question

- Thank you for allowing me to present our future plans for The Height Modernization for the State of Hawaii

- Any Questions?