

National Geodetic Survey

Products Update

USACE – New Orleans District
June 19, 2014



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Presentation Outline

- 1. - Overview of NGS Website**
- 2. - Current & Future US Datums**
- 3. - OPUS Suite of Products**

Datums - Horizontal

Horizontal

North American Datum Of 1927

- Used early triangulation surveys (first called US Std Datum).
- Based at Meades Ranch, KS & used Clarke 1866 spheroid.

North American Datum of 1983

- Used 250,000 points (triangulation, Doppler, a few GPS pts).
- Based at geocentric location using Geodetic Ref. Sys. 1980.

Updates*

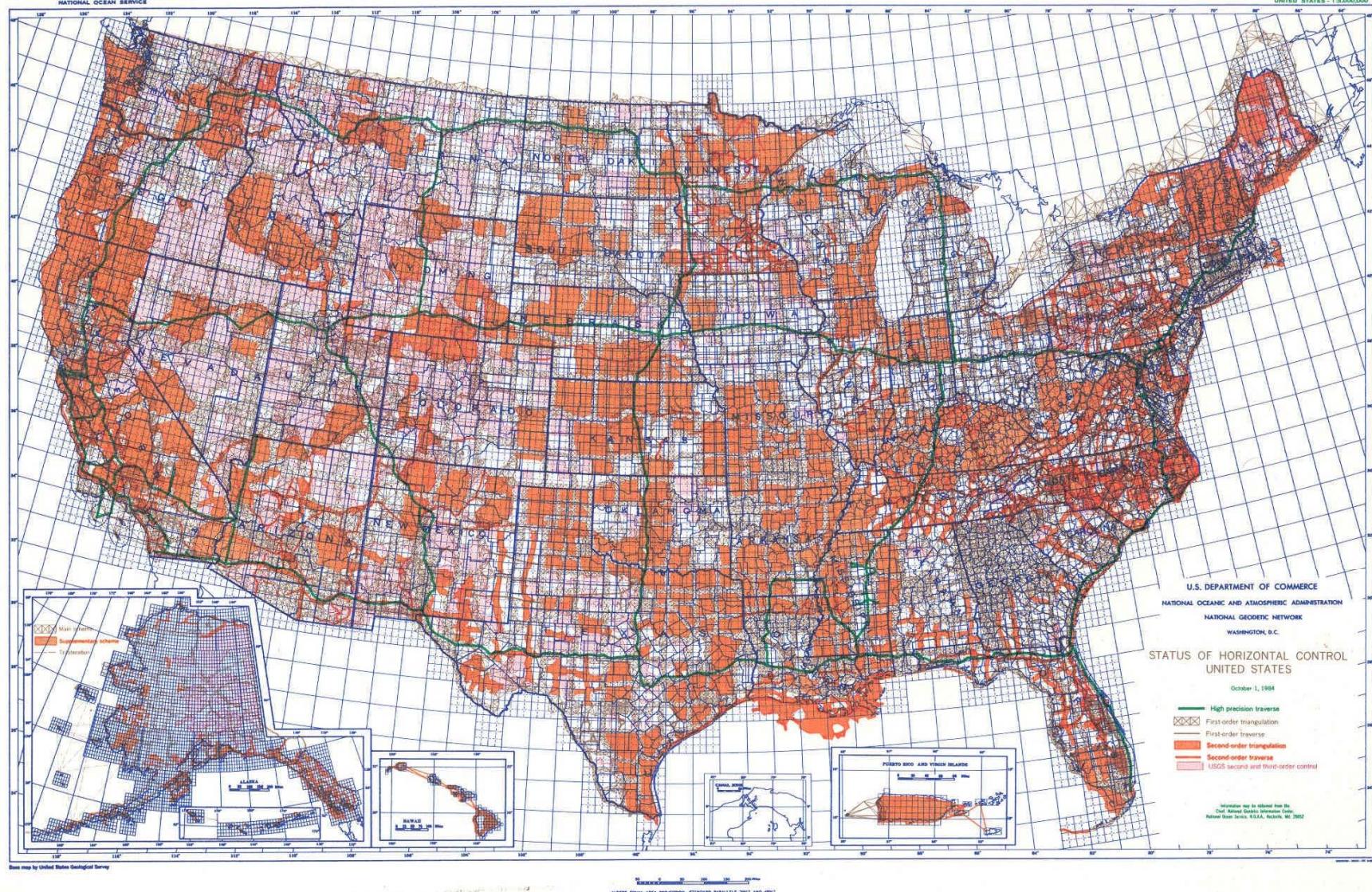
NAD83 (1990's) – State HARN / FBN surveys.

NAD83 (late 90's – early 2000's) – Efforts to establish ellipsoid heights.

NAD83 (2007) – Remove regional distortions, better with align CORS.

NAD83 (2011) – Adjustment to realign CORS / passive control.

* Not a new datums



Status of Horizontal Control, United States

National Spatial Reference System (NSRS) Improvements over time

| NETWORK | TIME SPAN | NETWORK ACCURACY | LOCAL ACCURACY | SHIFT |
|-------------------------------|-----------|------------------|---------------------------------|-----------|
| NAD 27 | 1927-1986 | 10 meters | (1:100,000) | 10-200 m |
| NAD83(86) | 1986-1990 | 1 meter | (1:100,000) | 0.3-1.0 m |
| NAD83(199x)* “HARN”, “FBN” | 1990-2007 | 0.1 meter | (1:1 million) (1:10 million) | 0.05 m |
| NAD83(NSRS2007) | 2007-2011 | 0.01 meter | 0.01 meter | 0.03 m |
| NAD83(NSRS2011) | 2011 | 0.01 meter | 0.01 meter | 0.01 m |

130°W 125°W 120°W 115°W 110°W 105°W 100°W 95°W 90°W 85°W 80°W 75°W 70°W 65°W

TXAC
ANAHUAC
Anahuac, TX
USA

Site operated by:
[TXDOT](#)

National Geodetic Survey - CORS



Coordinates

[SiteLog](#)
[Photographs](#)
[Data Availability](#)
[Standard Files](#)
[Custom Files \(UFCORS\)](#)

[Time Series \(short-term\)](#)
[Time Series \(long-term\)](#)

[Google Map all CORS](#)

Enter SiteID

[CORS Home](#)



115°W 110°W 105°W 100°W 95°W 90°W 85°W 80°W 75°W

Why Replace NAD83?

- NAD83 is NON-geocentric & hence inconsistent w/GNSS
- Difficult to maintain consistency between CORS & passive networks
- NAD 83 does not track/report passive mark motion
- Lack of monumentation stability / permanency
- Necessary for agreement with future ubiquitous positioning capability

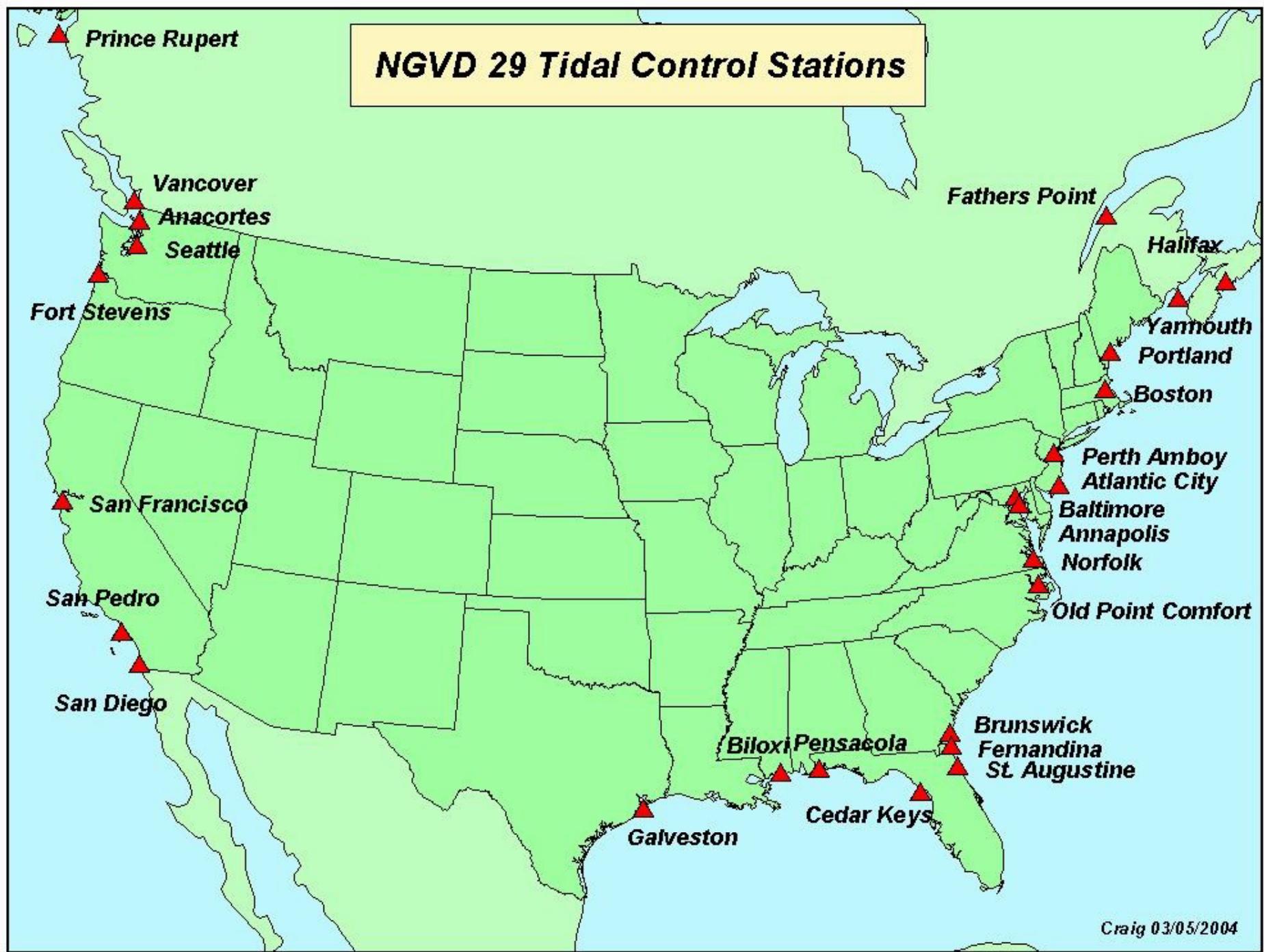
Datums - Vertical

National Geodetic Vertical Datum of 1929

- Based on heights at 26 tide stations along US & Canadian coast.
- Used 75,000 Km (US) & 30,000 Km (Can.) of leveling data.
- Adjustment constrained to the 26 tide stations.
- Based at geocentric location using Geodetic Ref. Sys. 1980.

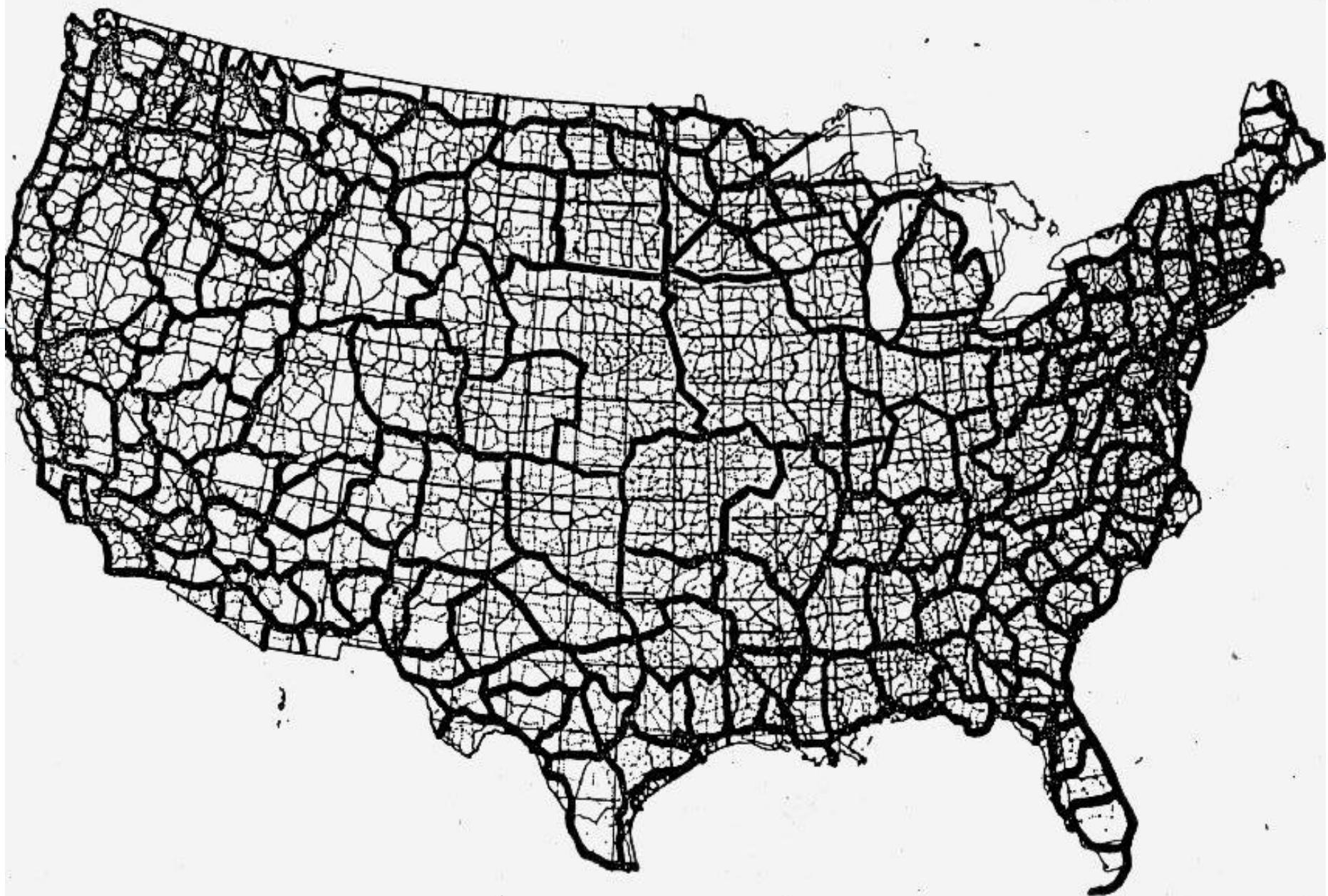
North American Vertical Datum of 1988

- Approx. 650,000 Km of new leveling since NGVD 1929.
- Based on (constrained to) agreed upon mark in Great Lakes Region (Father's Point).
- Greatly improved vertical accuracy over NGVD 1929 datum.
- Defined only on the conterminous North American continent
- Does not (and cannot) exist for any place you can't level to from Father Point, such as:
 - Guam, American Samoa, Hawaii, Puerto Rico, American Virgin Islands, Commonwealth of the Northern Marianas, Aleutian Islands



Craig 03/05/2004

NAVD 88 NEW ADJUSTMENT PROJECT



NORTH AMERICAL VERTICAL DATUM 1988 (NAVD88)



Problems with NAVD 88

- **NAVD 88 relies upon bench marks that:**
 - Disappear by the thousands every year
 - Are not funded for replacement
 - Are almost never re-checked for movement
 - Are affected by freeze / thaw, subsidence, uplift, etc.
 - Are not necessarily in convenient places
 - Cross-country error build up

NAVD 88 suffers from a zero height surface that:

- Has been proven to be ~50 cm biased from the latest, best geoid models (GRACE satellite)
- Has been proven to be ~ 1 meter tilted across CONUS (again, based on the independently computed geoid from the GRACE satellite)



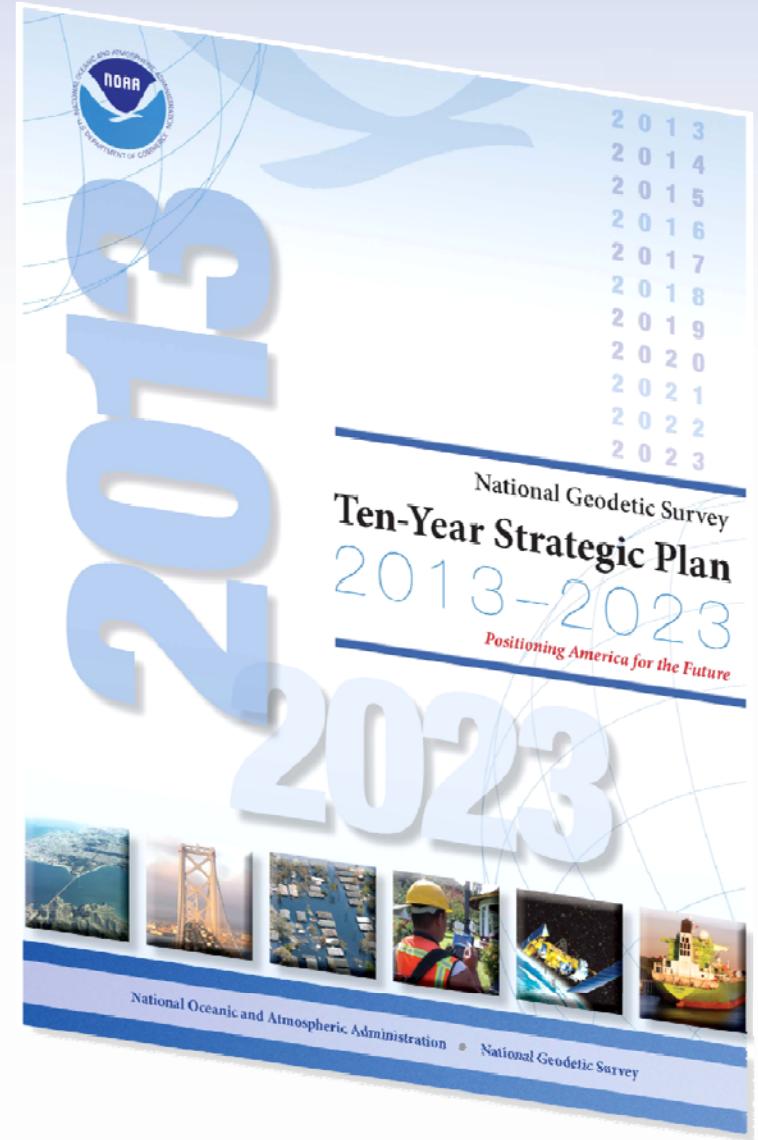
NEW National Geodetic Survey Ten-Year Plan

- ❖ By 2022, reduce all definitional & access-related errors in geometric reference frame to 1 cm when using 15 min of GNSS data

“Replace NAD83”

- ❖ By 2022, reduce all definitional & access-related errors in orthometric heights in geopotential reference frame to 2 cm when using 15 min of GNSS data

“Replace NAVD88”



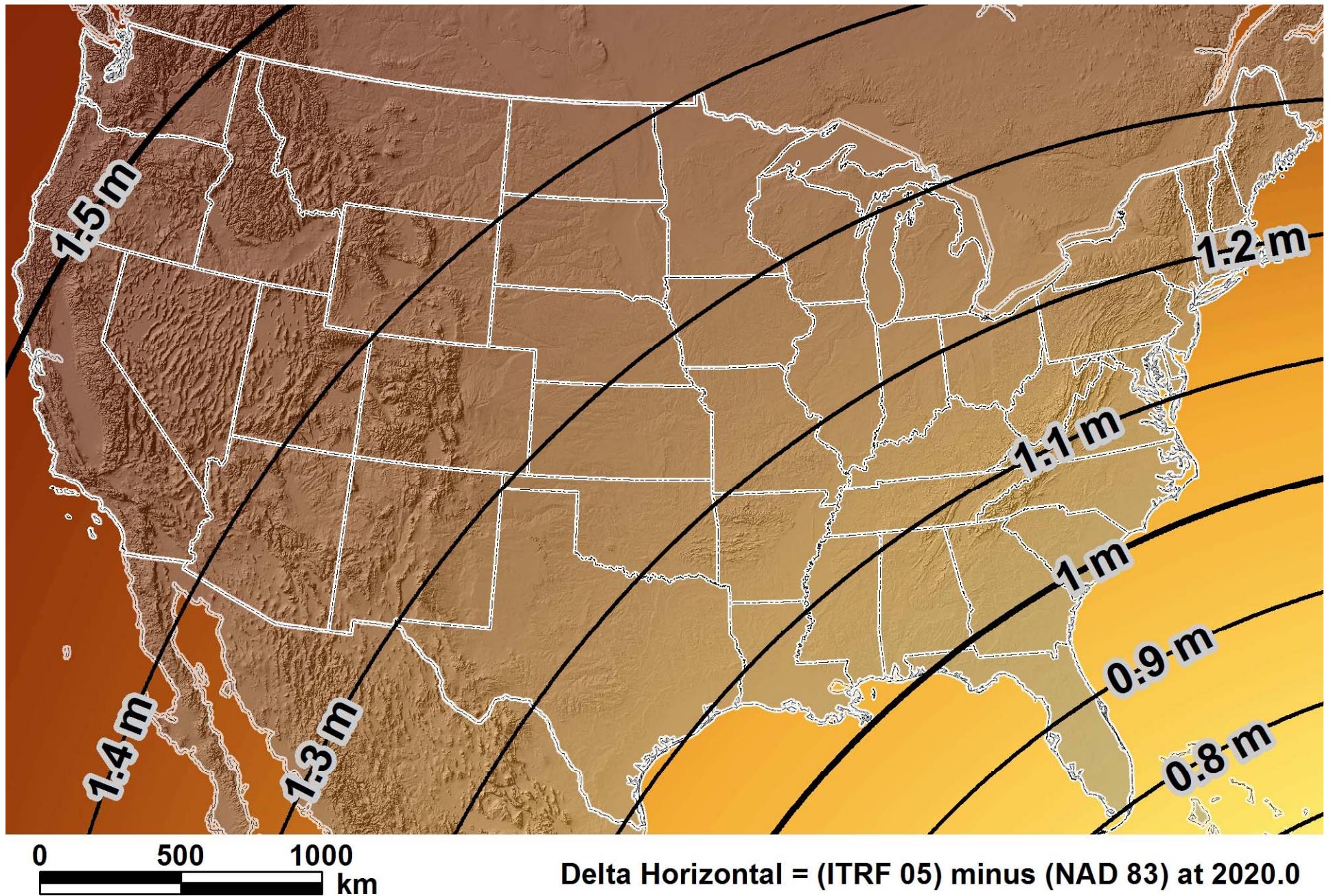
Future Geometric (3-D) Datum

- replace NAD83 with new geometric datum – by 2022
- CORS-based, accessed via GNSS observations
- coordinates & velocities in ITRF & official US datum & relationship
- (NAD83 replacement: plate-fixed or “ITRF-like”?)
- passive control tied to new datum; not a component of new datum
- address user needs of datum coordinate constancy vs. accuracy

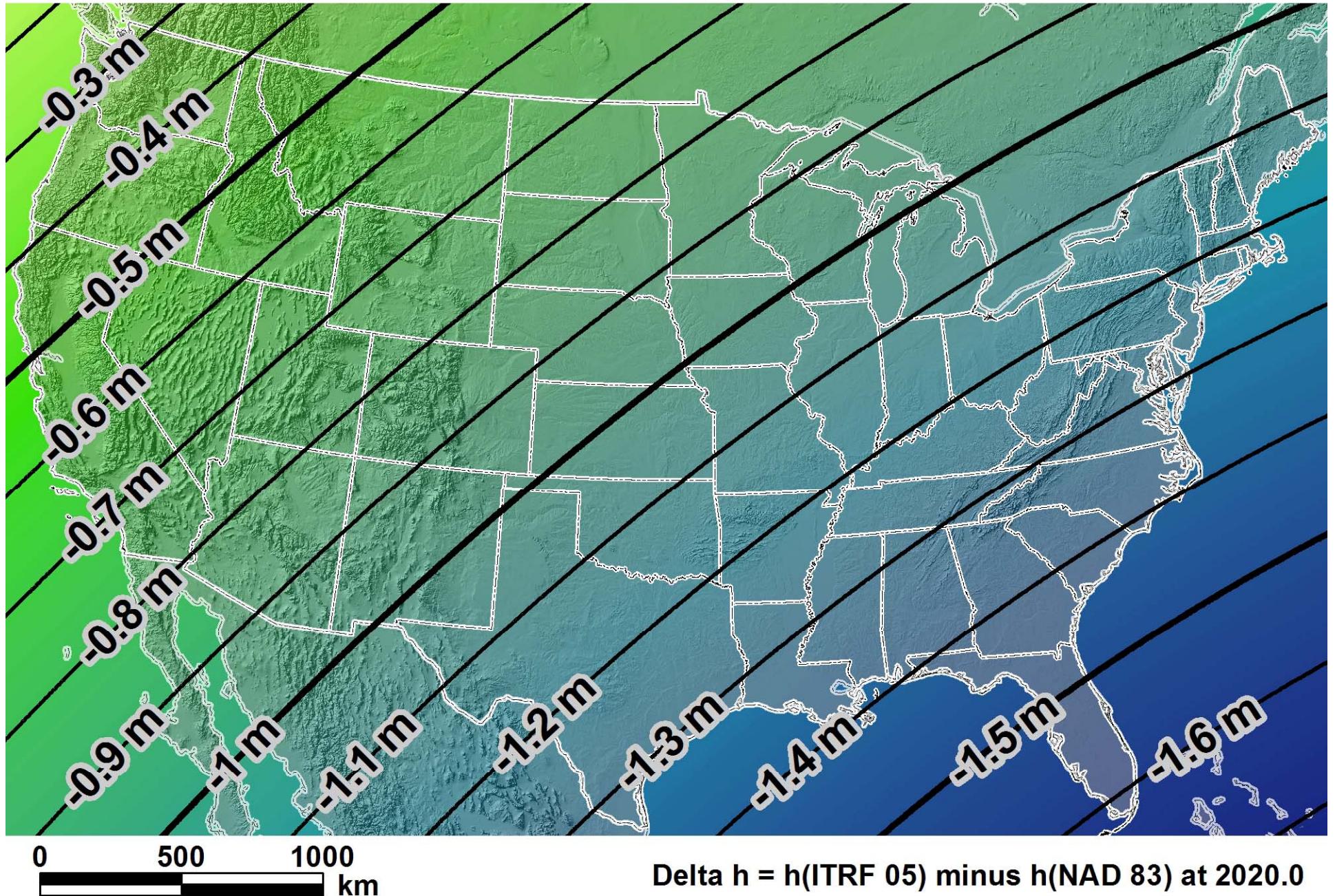
Future Geopotential (Vertical) Datum

- By 2022 replace NAVD88
- Would be most accurate continental gravimetric geoid model to date - **1 cm accuracy**
- Determine orthometric heights through GNSS & gravimetric geoid – **2 cm accuracy anywhere in N.A.**
- Monitor time-varying nature of gravity field

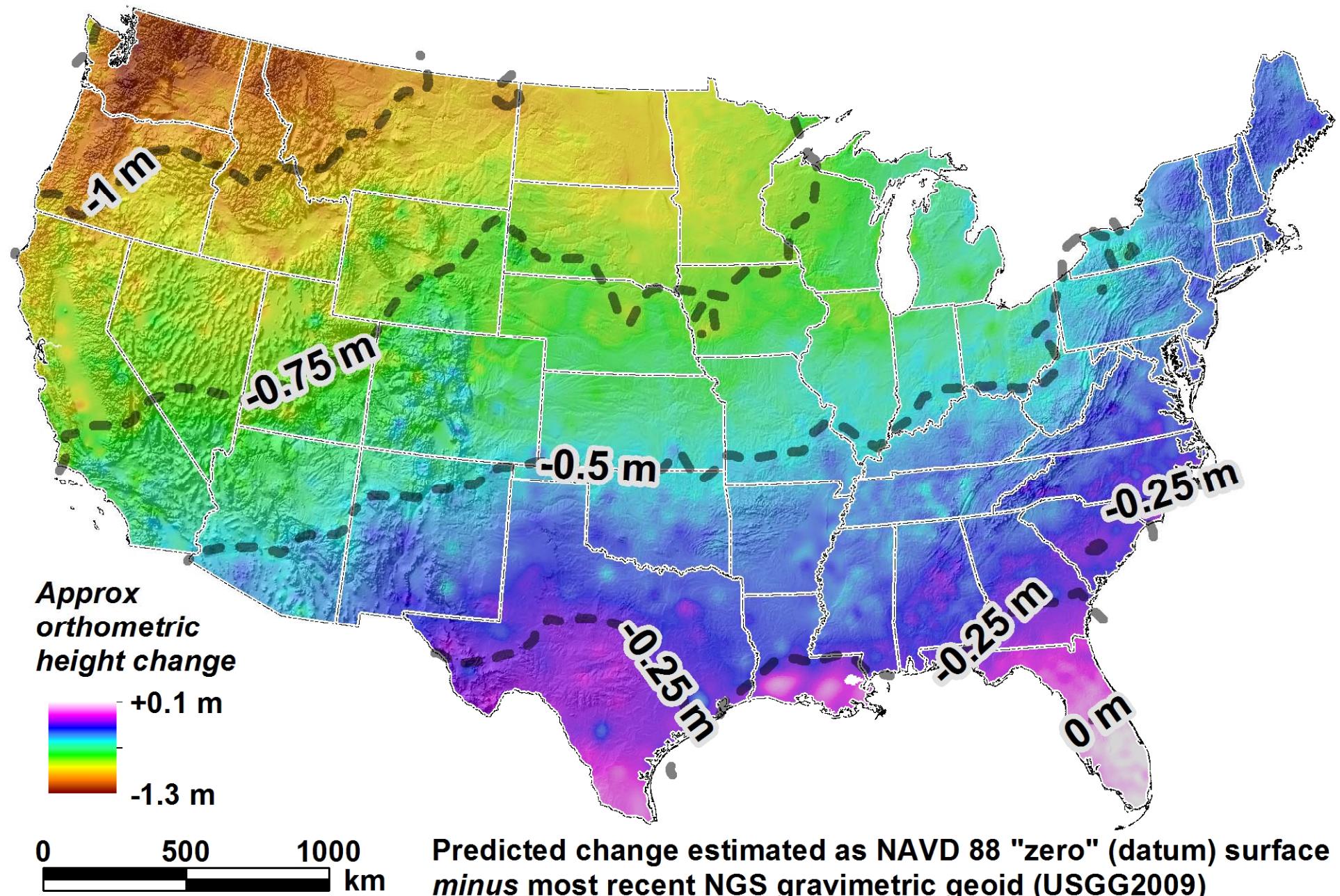
Estimated horizontal change from NAD 83 to new geometric datum



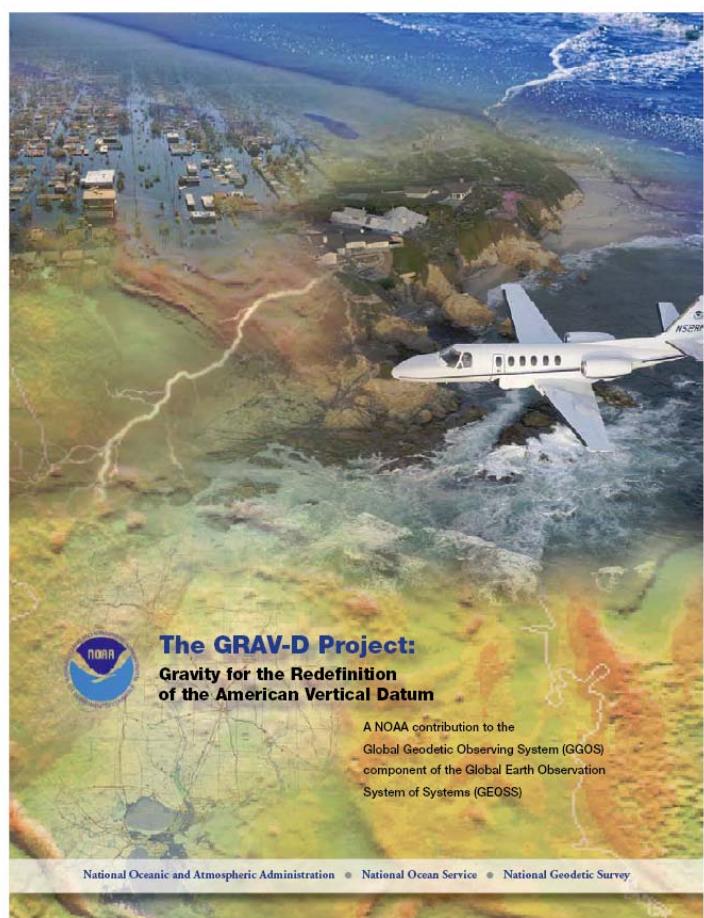
Estimated ellipsoid height change from NAD 83 to new geometric datum



Approximate predicted change from NAVD 88 to new vertical datum



What is GRAV-D?

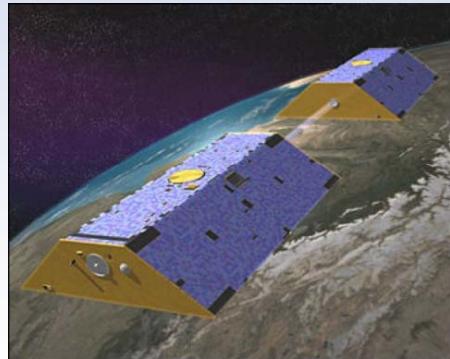


- Official NGS policy as of Nov 14, 2007 as part of 10 yr plan 2008-18
 - Estimated \$38.5M over 10 years
- Three thrusts of project:
 - Airborne survey “snapshot”
 - Long-term monitoring of geoid change
 - Partnership surveys
- Re-define the Vertical Datum of the USA by 2022 (given funding levels)

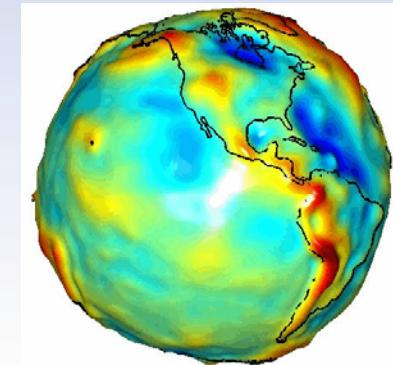
**Gravity and Heights are
inseparably connected**

Building a Gravity Field

GRACE Satellite



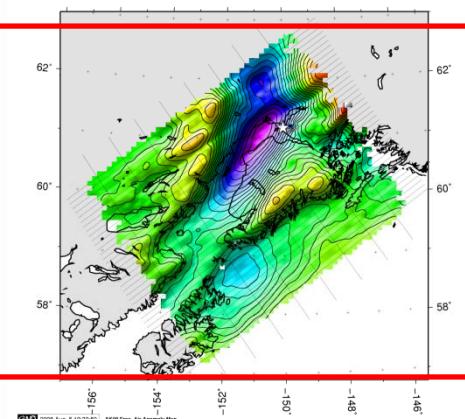
Long Wavelengths:
 $(\geq 350 \text{ km})$



Airborne Measurement



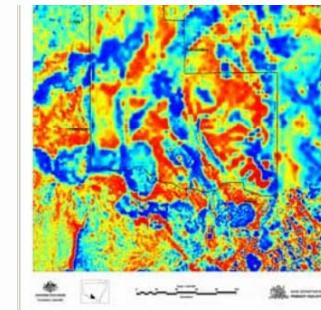
Intermediate Wavelengths
(500 km to 20 km)



Surface Measurement

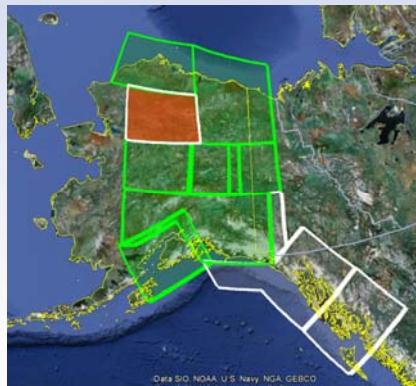


Short Wavelengths
($< 200 \text{ km}$)



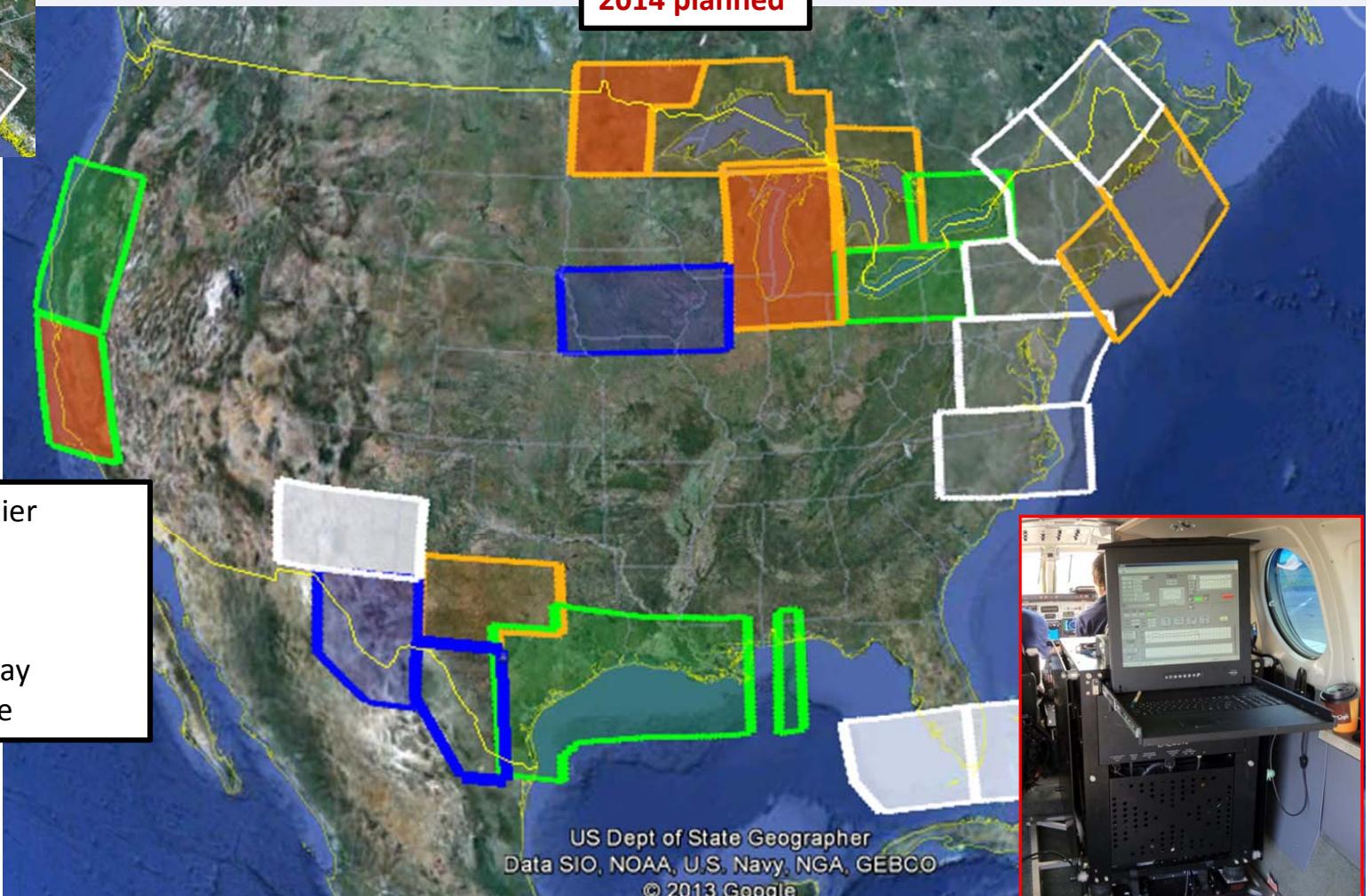
GRAV-D Status

- 10 km spaced data lines
- 70 km spaced cross lines
- 20,000 ft altitude
- 230 kt flight speed
- 25% of US complete



2013 flown
2014 planned

Green = FY11 and earlier
Orange = FY12
White = FY13
Blue = FY14 Plan
Filled white = Underway
Filled red = Incomplete



Geoid Slope Validation Survey – 2011 (GSVS11)



- Observe geoid shape (slope) using multiple independent terrestrial survey methods
 - GPS + Leveling
 - Deflections of the Vertical
- Compare *observed* slopes (from terrestrial surveys) to *modeled* slopes (from gravimetry or satellites)
 - With / Without new GRAV-D airborne gravity

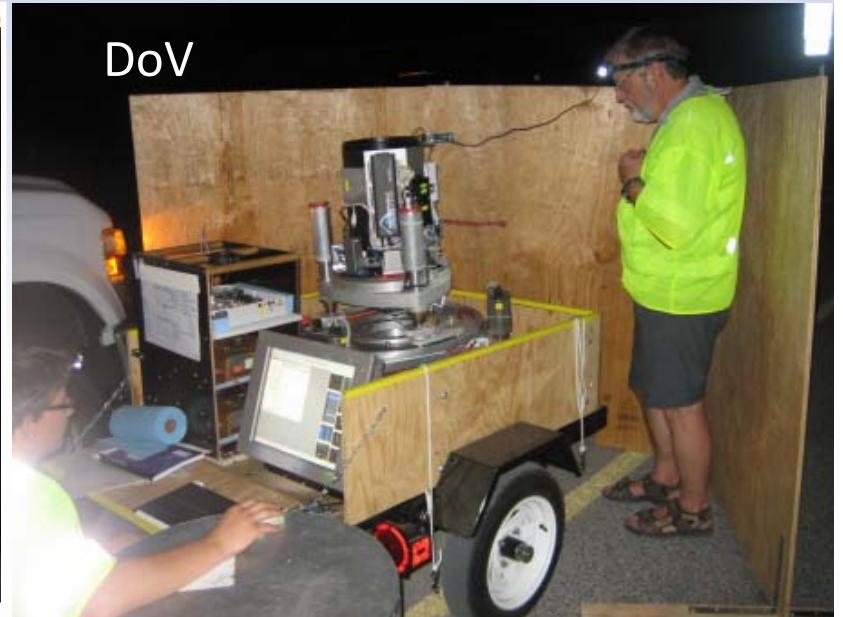
GSVS – 2011 (Texas)



GPS



LIDAR / Imagery



DoV

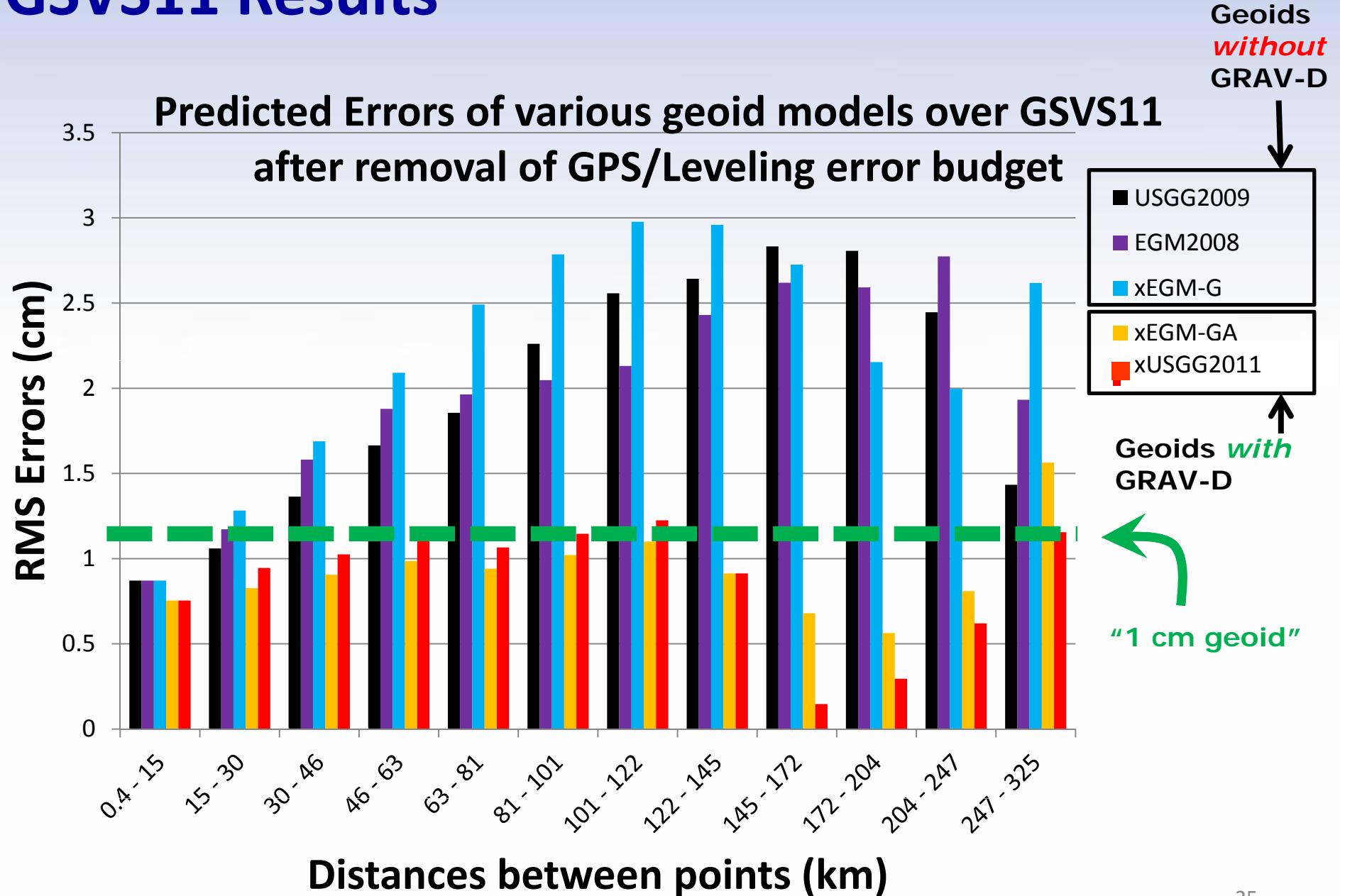


Leveling

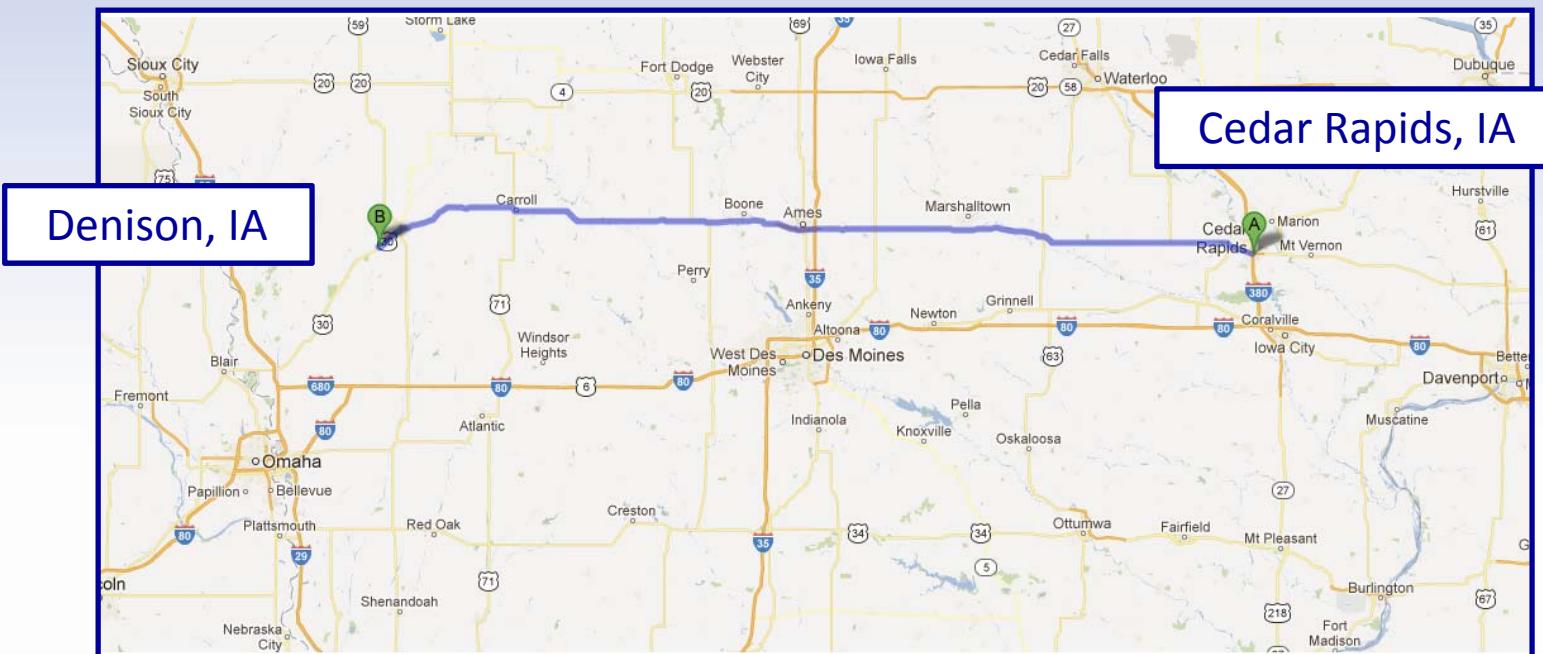


Gravity

GSVS11 Results



GSVS – 2014 (Iowa)

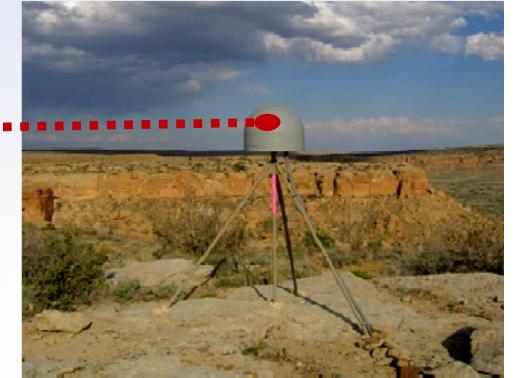
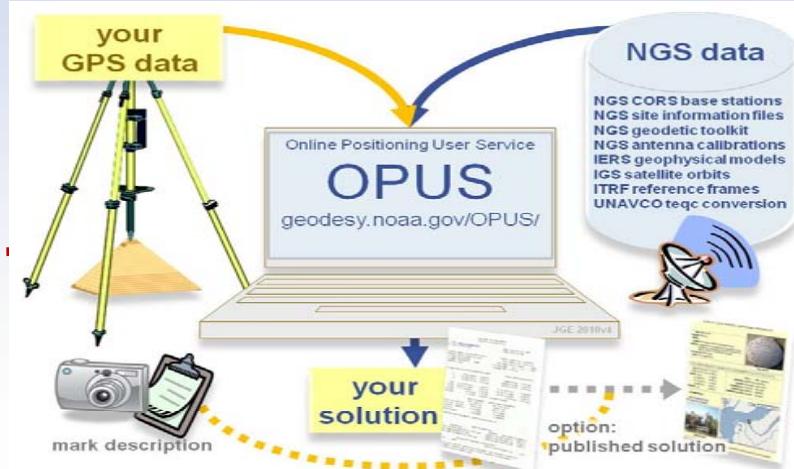


- Minimal Trees (GPS)
- No major bridges/water crossings (Leveling)
- Along roads (ease of access)
- Mostly cloud-free nights
- Under GRAV-D coverage (or will be)
- With at least some existent bench marks/NAVD 88 level lines
- A "significant enough" geoid slope to be interesting
- For GSVS11, we wanted "low and flat" topography. For GSVS14 we'll want to step this up to "high and flat" or possibly "medium high, more-or-less flat and gravimetrically complex"

How to Plan for 2022

- **Move to NAD 83(2011) epoch 2010.00**
 - NADCON and new conversion tools (GEOCON & GEOCON11)
- **Move to NAVD 88**
 - understand the accuracy of VERTCON in your area
- **Move from reliance on passive marks to GNSS**
 - utilize CORS, OPUS, regional real-time infrastructure, etc.
- **Use OPUS for GPSBMs**
 - improve next geoid model & relationship with new datum

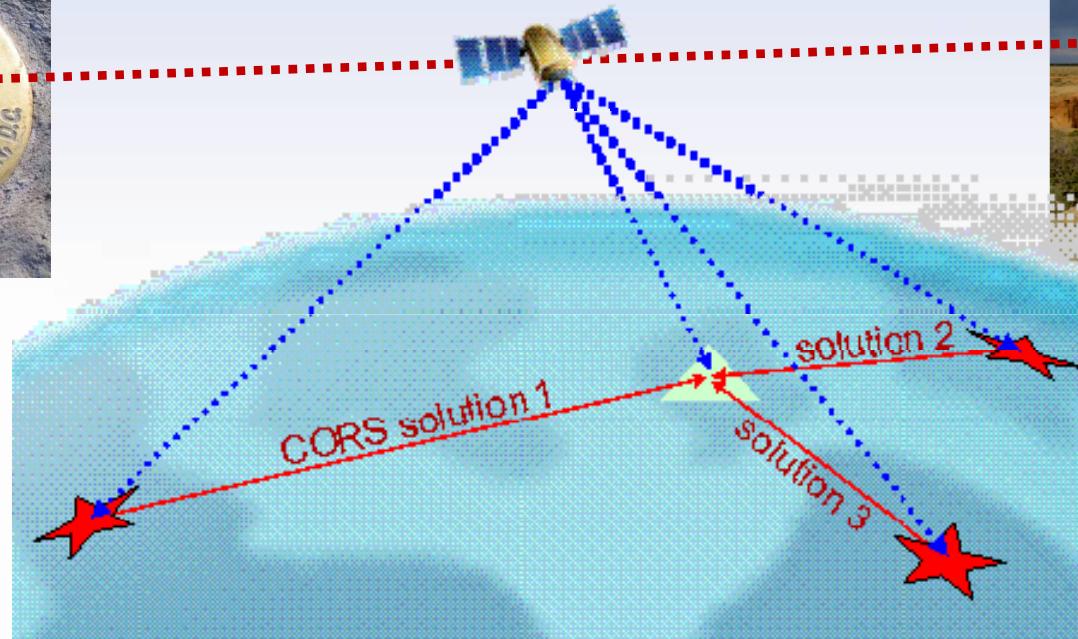
Online Positioning User Service (OPUS)



- upload L1/L2 GPS data
 - OPUS-RS (Rapid Static) ----15 min to 2 hr (per CORS)
 - OPUS-S (Static) ---- 2 to 48 hr (anywhere)
- solution via email ---- in minutes
- optional sharing (formerly “publishing”)
- OPUS-Projects

>>> fast, easy
NSRS access

Online Positioning User Service (OPUS)



- >15 min of L1/L2 GPS data >>> geodesy.noaa.gov/OPUS/
- Processed automatically on NGS computers, tied to CORS
- Solution via email - in minutes

Fast, easy, consistent access to NSRS

OPUS Solution Report

USER: william.stone@noaa.gov
RINEX FILE: 4cor188c.11o

DATE: November 08, 2012
TIME: 22:49:53 UTC

SOFTWARE: page5 1209.04 master3.pl 0821123 START: 2011/07/07 02:16:00
EPEHemeris: igs16434.eph [precise] STOP: 2011/07/07 13:01:00
NAV FILE: brdc1880.11n OBS USED: 27005 / 27983 : 97%
ANT NAME: ASH701975.01AGP NONE # FIXED AMB: 111 / 123 : 90%
ARP HEIGHT: 2.00 OVERALL RMS: 0.015(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2011.5132)

| | | | | |
|----|-----------------|----------|-----------------|----------|
| X: | -1664599.631(m) | 0.011(m) | -1664600.408(m) | 0.011(m) |
| Y: | -4821995.066(m) | 0.018(m) | -4821993.736(m) | 0.018(m) |
| Z: | 3818181.574(m) | 0.012(m) | 3818181.479(m) | 0.012(m) |

| | | | | |
|------------|-----------------|----------|------------------------------------|----------|
| LAT: | 36 59 56.31614 | 0.014(m) | 36 59 56.33327 | 0.014(m) |
| E LON: | 250 57 17.37962 | 0.005(m) | 250 57 17.33238 | 0.005(m) |
| W LON: | 109 2 42.62038 | 0.005(m) | 109 2 42.66762 | 0.005(m) |
| EL HGT: | 1460.798(m) | 0.021(m) | 1459.940(m) | 0.021(m) |
| ORTHO HGT: | 1481.553(m) | 0.039(m) | [NAVD88 (Computed using GEOID12A)] | |

UTM COORDINATES STATE PLANE COORDINATES
UTM (Zone 12) SPC (3003 NM W)

| | | |
|-----------------------|-------------|-------------|
| Northing (Y) [meters] | 4096544.996 | 666054.156 |
| Easting (X) [meters] | 673944.600 | 722137.490 |
| Convergence [degrees] | 1.17671176 | -0.72935589 |
| Point Scale | 0.99997275 | 1.000005994 |
| Combined Factor | 0.99974356 | 0.99983073 |

US NATIONAL GRID DESIGNATOR: 12SXF7394496544(NAD 83)

BASE STATIONS USED

| PID | DESIGNATION | LATITUDE | LONGITUDE | DISTANCE(m) |
|--------|--------------------------------|-------------|--------------|-------------|
| DH5816 | P028 CHACOCNHP_NM2005 CORS ARP | N360154.048 | W1075430.227 | 147987.2 |
| DI3419 | P012 MONTICELLOUT2006 CORS ARP | N380550.740 | W1092001.763 | 124584.7 |
| DL3642 | MC09 NUCLA CORS ARP | N381435.614 | W1083329.283 | 144670.7 |

NEAREST NGS PUBLISHED CONTROL POINT

| | | | | |
|---------|---------------------------|-------------|--------------|-------|
| GO00510 | BOUNDARY MI COR 330 CO NM | N365956.309 | W1090235.673 | 171.6 |
|---------|---------------------------|-------------|--------------|-------|

OPUS – Sharing (aka OPUS-DB)

Sharing Criteria:

- NGS-calibrated GPS antenna
- > 4 hour data span (OPUS-S)
- > 70% observations used
- > 70% fixed ambiguities
- < 0.04m H / 0.08m V peak-to-peak

Applications:

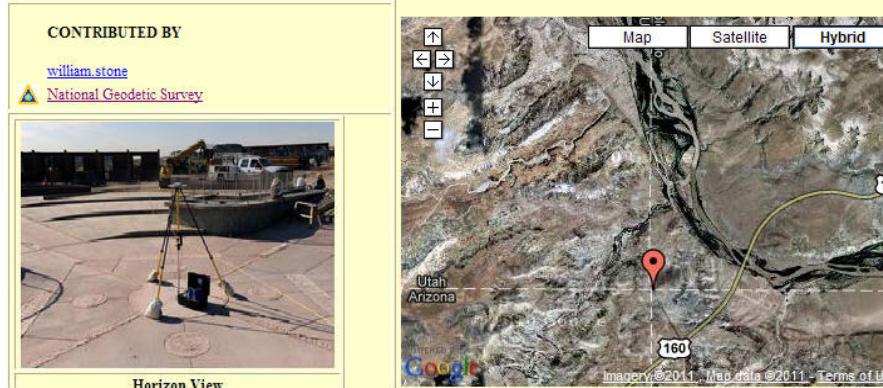
- ✓ GPS on BMs (geoid modeling)
- ✓ PLSS / GCDB
- ✓ Data-sharing/archive

PID: BBCD57
Designation: FOUR CORNERS 2010
Stamping: COLORADO UTAH ARIZONA NEW MEXICO 1992
Stability: Monument will probably hold position well
Setting: Mat foundation or concrete slab other than pavement
Description: THE STATION IS THE CENTER OF AN 8-INCH DIAMETER BRASS USDOI/BLM DISK MARKING THE POINT COMMON TO COLORADO, UTAH, ARIZONA, AND NEW MEXICO. IT IS LOCATED AT THE NAVAJO NATION'S FOUR CORNERS MONUMENT, MANAGED BY THE NAVAJO PARKS AND RECREATION DEPARTMENT, TEL: 928-871-6647. THE FOUR CORNERS MONUMENT INSTALLED IN 1992 (NGS PID: AD9256, NOW CONSIDERED DESTROYED) WAS REMOVED AND THE DISK RESET IN 2010 DURING RECONSTRUCTION OF THE MONUMENT AND VISITOR PLAZA. THE DISK WILL EVENTUALLY BE STAMPED "2010."
Observed: 2010-07-07T22:39:00Z
Source: OPUS - page5 1009.28

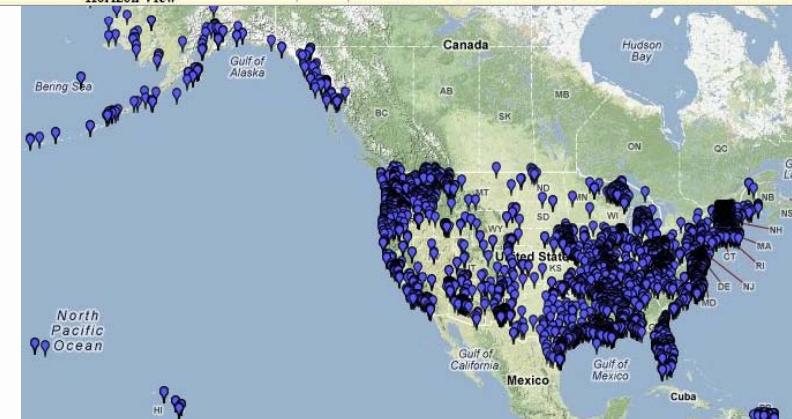


Close-up View

| RFF_FRAME: | NAD_83 (COR96) | EPOCH: | 2002.0000 | SOURCE: | NAD83 (Computed using GEOID09) | UNITS: | SFT PROFILE | DETAILS |
|------------|--------------------|-----------|-----------|------------------|-----------------------------------|--------------|----------------|---------|
| LAT: | 36° 59' 56.31568" | ± 0.027 m | | UTM 12 | SPC 3003(NW) | | | |
| LON: | -109° 2' 42.62051" | ± 0.011 m | | NORTHING: | 4096544.982m | 666054.142m | | |
| ELL HT: | 1460.802 | ± 0.003 m | | EASTING: | 673944.597m | 722137.487m | | |
| X: | -1664599.638 | ± 0.015 m | | CONVERGENCE: | 1.17671173° | -0.72935591° | | |
| Y: | -4821995.076 | ± 0.009 m | | POINT SCALE: | 0.99997275 | 1.00005994 | | |
| Z: | 3818181.565 | ± 0.023 m | | COMBINED FACTOR: | 0.99974356 | 0.99983074 | | |
| ORTHO HT: | 1481.544 | ± 0.016 m | | | | | | |



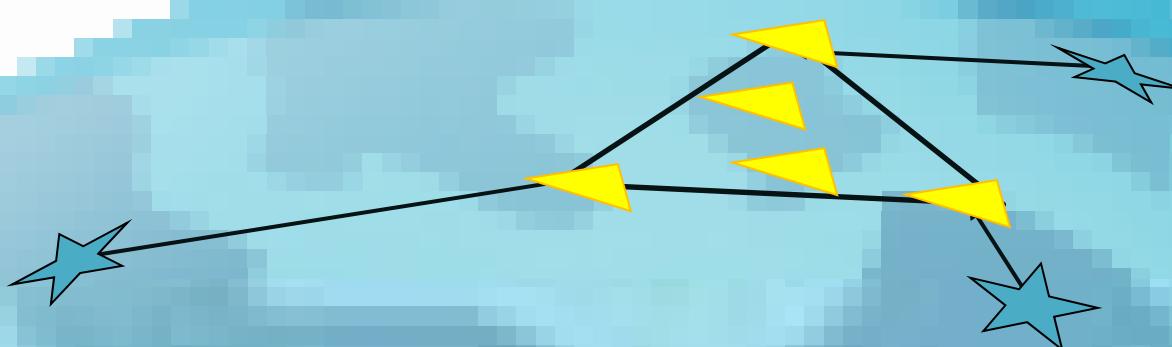
Horizon View



OPUS-projects:

first, submit data through OPUS with project ID

OPUS automatically forms sessions from simultaneously observed marks, enabling multi-baseline processing and adjustment of redundant observations.



Improved solutions for simultaneous or repeated observations

*harvest data from multiple observers
share upload & processing tasks
customize your processing using PAGES*

*simple data quality analysis
improve survey accuracy
constrain to local networks
publishing support (limited)*



OPUS Projects

National Geodetic Survey



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OPUS Projects gives users web-based access to simple management and processing tools for projects involving multiple sites and multiple occupations. The advantages of OPUS Projects are:

- Data uploading through OPUS.
- Customizable data processing via the PAGES software suite.
- Visualization and management aids.

Create a new project.

[Create](#)

RESTRICTED to trained project managers. If you have completed OPUS Projects training, you are registered and may create a new project. All others, see the [Training Schedule](#).

Configure, edit, and process individual network sessions.

[Session](#)

Project Identifier:

Session Keyword:

Your Email:

Manage, edit, process, and publish the project.

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Project Identifier:

Manager Keyword:

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?? Questions ??

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