

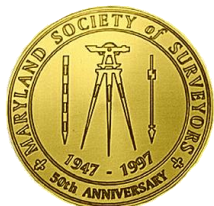


Modernization of the National Spatial Reference System **Keeping Pace with Changes in Positioning Technology and** **User Expectations in a Dynamic World**

Maryland Society of Surveyors
Gaithersburg
October 17, 2014

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Acting Chief, Observations and Analysis Division
National Geodetic Survey (NGS)
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Dave Doyle
NGS Chief Geodetic Surveyor (Retired)
base9geodesy@gmail.com



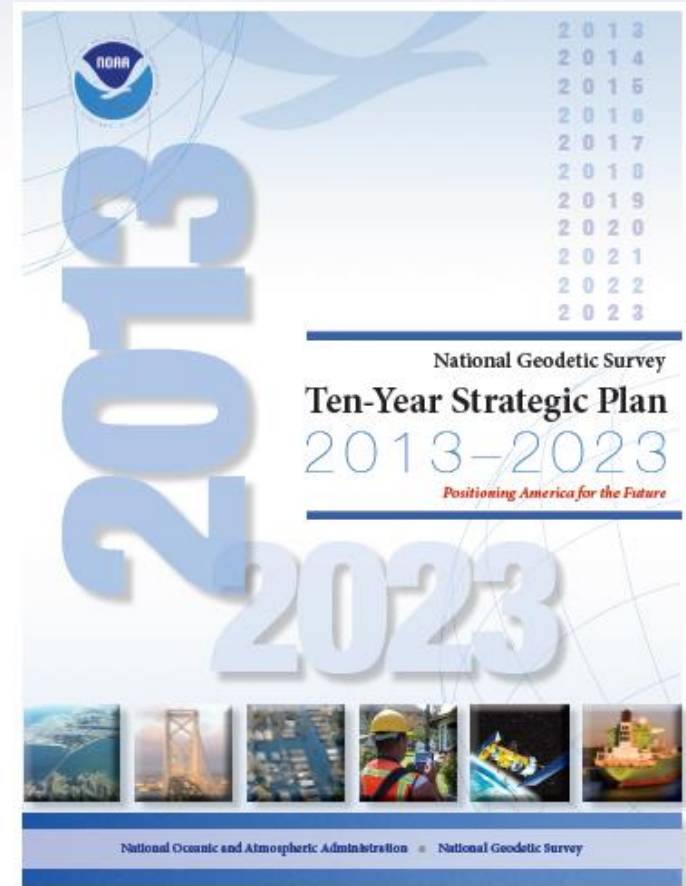
The National Geodetic Survey 10 year plan

Mission, Vision and Strategy

2013 – 2023

http://www.ngs.noaa.gov/web/news/Ten_Year_Plan_2013-2023.pdf

- Official NGS policy as of Jan 31, 2013
 - To modernize and improve NSRS
 - Attention to accuracy
 - Attention to time-changes
 - Improved products and services
 - Fully vetted by NSPS/AAGS
- 2022 Targets:
 - Replace NAD 83 and NAVD 88
 - Cm-accuracy access to all coordinates



Problems with NAD 83 and NAVD 88

NAD 83 is not as geocentric as it could be (approx. 1.5 m for CONUS).

Surveyors don't see this – Yet

NAD 83 is not well defined with positional velocities

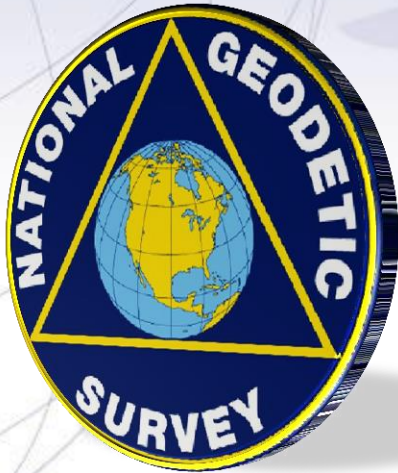
NAVD 88 is realized by passive control (bench marks) most of which have
Not been releveled in 30-40 years

NAVD 88 does not easily account for local vertical velocities (subsidence / uplift)

- ❖ Post glacial isostatic readjustment – Glacial forebulge collapse
- ❖ Subsurface fluid/hydrocarbon extraction
- ❖ Sediment loading - Compaction
- ❖ Sea level rise - Ocean City = + 5.5 mm/yr (1.6 ft in 100 years)
Baltimore = + 3.1 mm/yr (1.0 ft in 100 years)

NAVD 88 Leveled heights do not truly represent changes in gravity potential

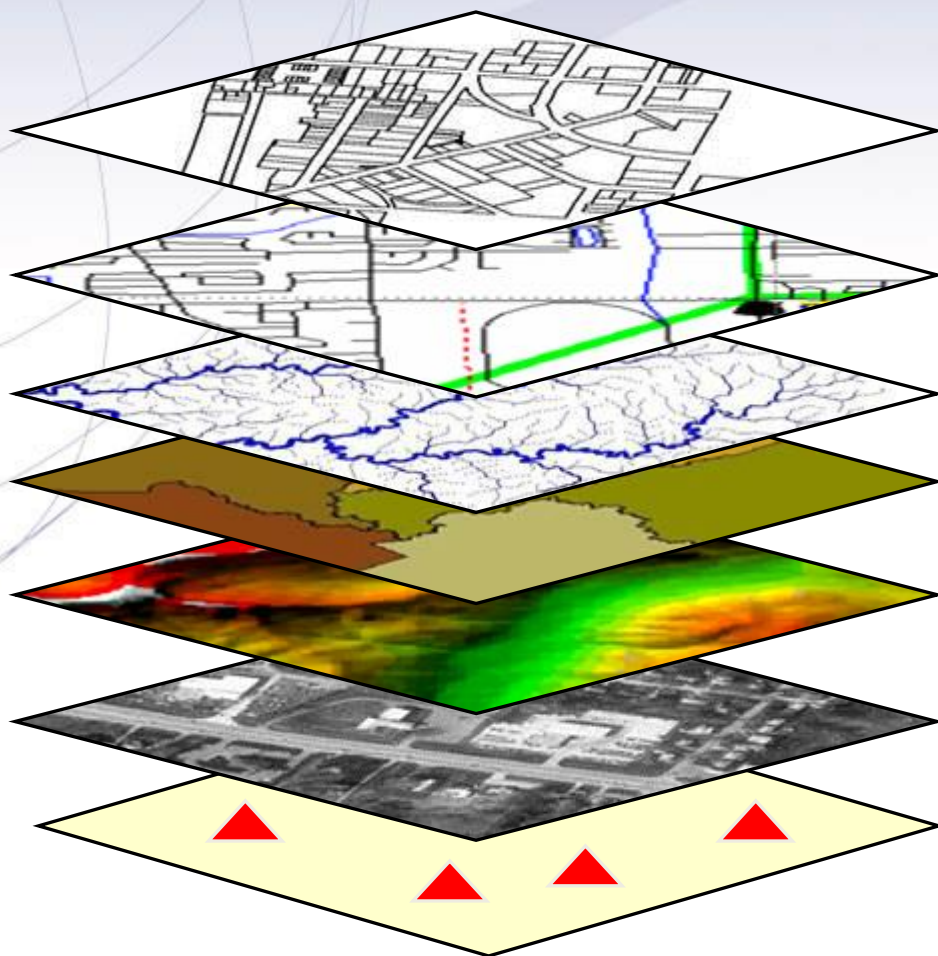
NGS Mission Statement



To define, maintain and provide access to the **National Spatial Reference System (NSRS)** to meet our nation's economic, social, and environmental needs.

The **NSRS** is a consistent coordinate system that defines latitude, longitude, height, scale, gravity, and orientation throughout the United States.

NSRS Provides the Geospatial *Foundation*



Land Ownership

Transportation

Surface Waters

Boundaries

Elevation

Aerial Imagery

Geodetic Control

The National Spatial Reference System supports



Nautical charts, among many other geospatial applications
National Oceanic and Atmospheric Administration



Emergency Response Imagery, Flood zones for the
National Flood Insurance Program
Federal Emergency Management Agency



Levee Safety Program to determine levee heights & positions
United States Army Corps of Engineers



Topographic Maps and interior water data for the nation
United States Geological Survey



NSRS gravity data for the geospatial mission of NGA
National Geospatial-Intelligence Agency



Aeronautical Data Quality Assurance
Federal Aviation Administration

Federal Geographic Data Committee

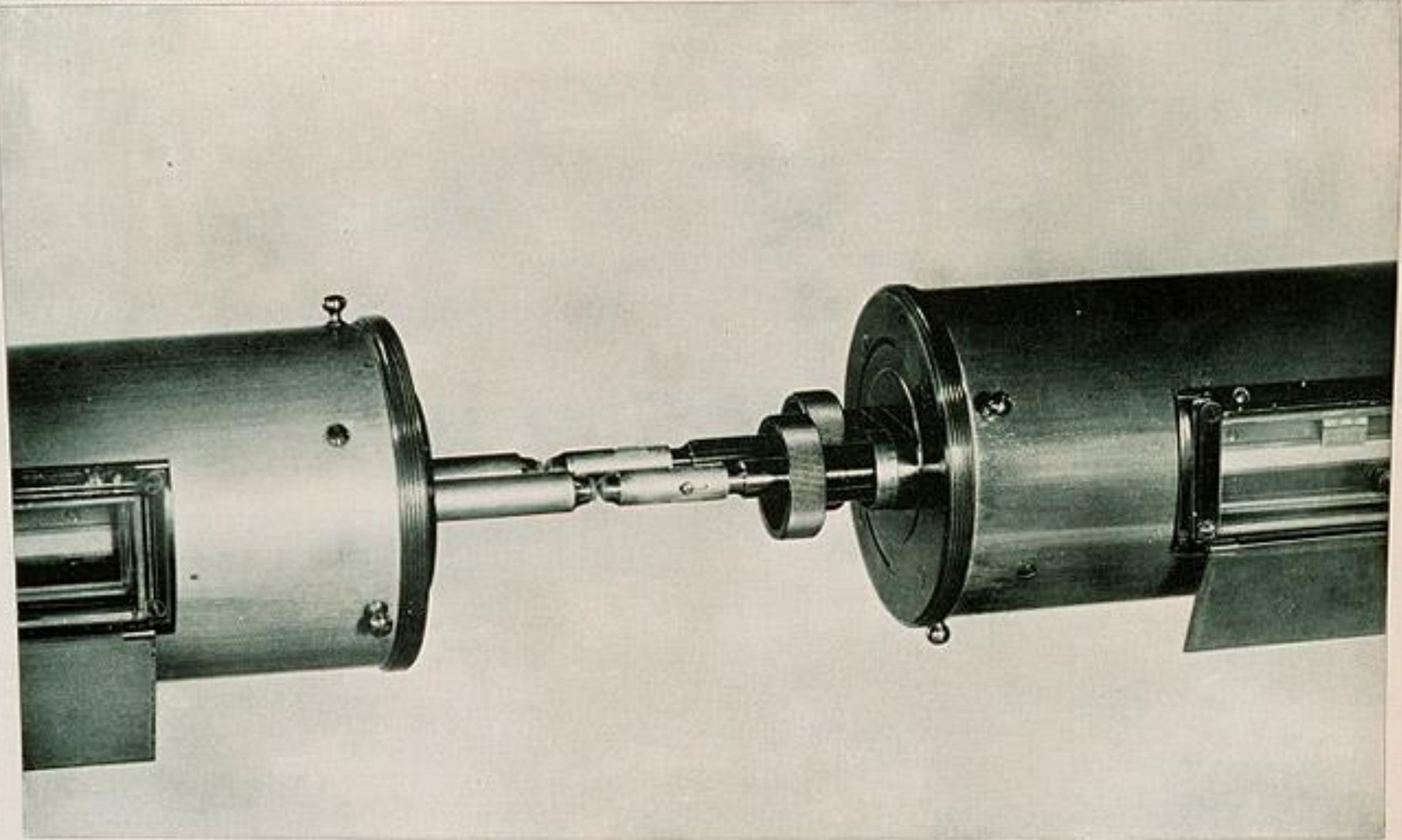


- Promotes the coordinated development, use, sharing and dissemination of geospatial data nationally
- NGS is the lead agency responsible for coordinating geodetic data-related activities among Fed and non-Fed agencies

Cutting Edge Surveying Technology circa 1890

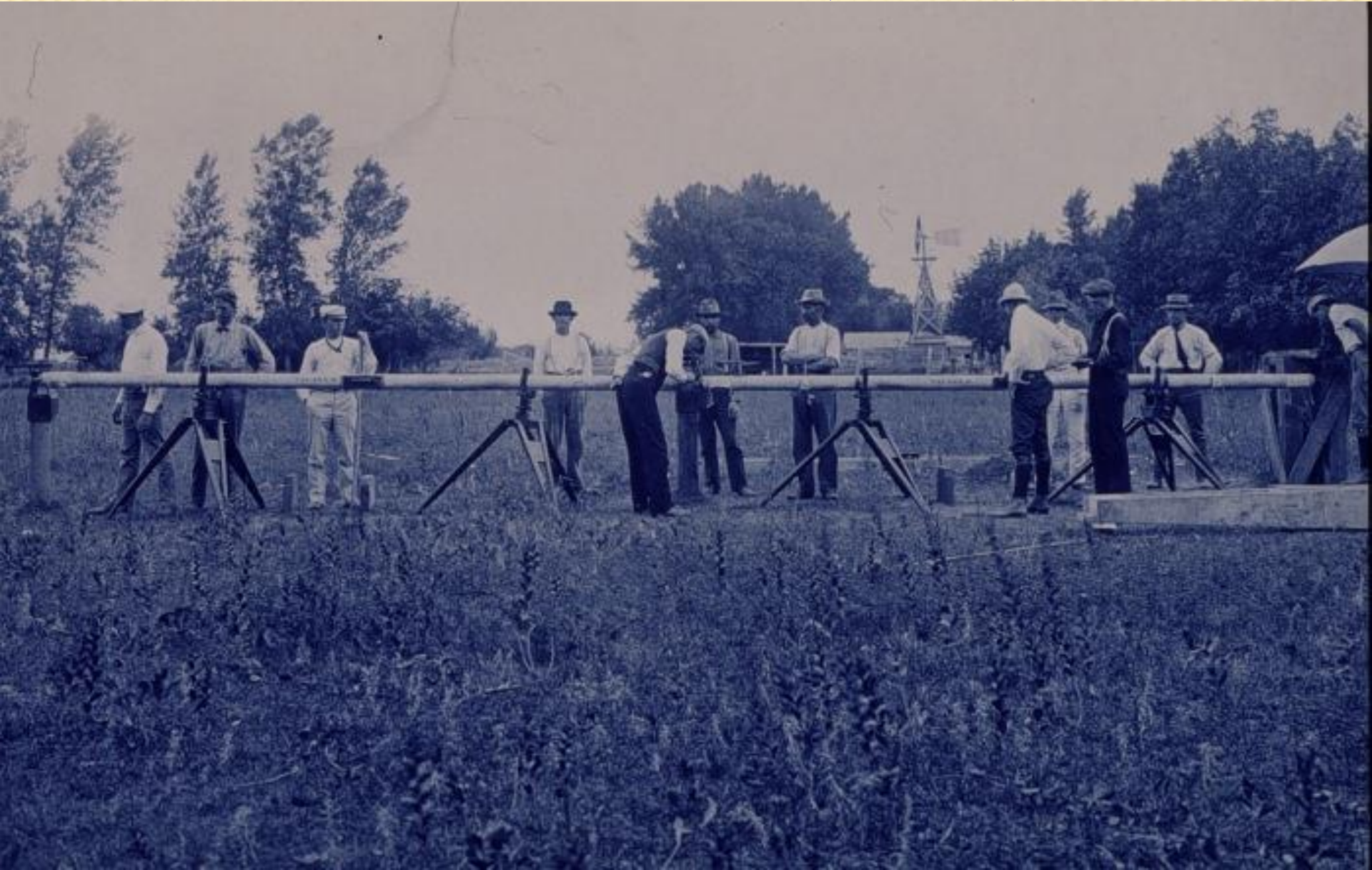
U. S. Coast and Geodetic Survey Report for 1897. Appendix No. 11.

Fig. 3.



DUPLEX BARS IN CONTACT—FACE DOWN.

Salina, KS Baseline Measurement – 1896
6.5 km/4.1 mi required about 5 weeks
Precision ~ 8 mm/0.03 ft (1:721,600)



Advances in distance measurement technology

Early 1900s



Electronic technology 1950s - 1970



A Game Changer

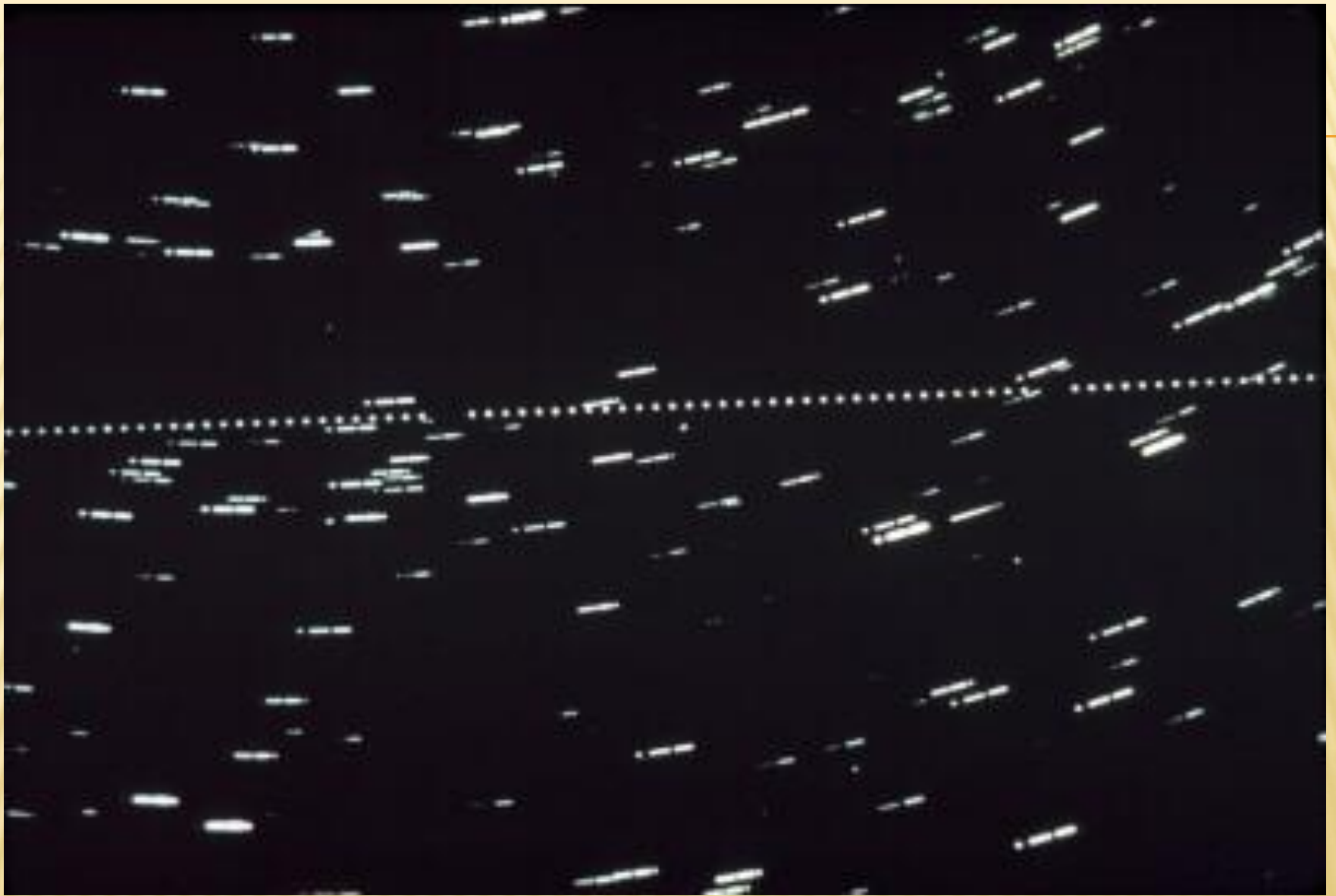




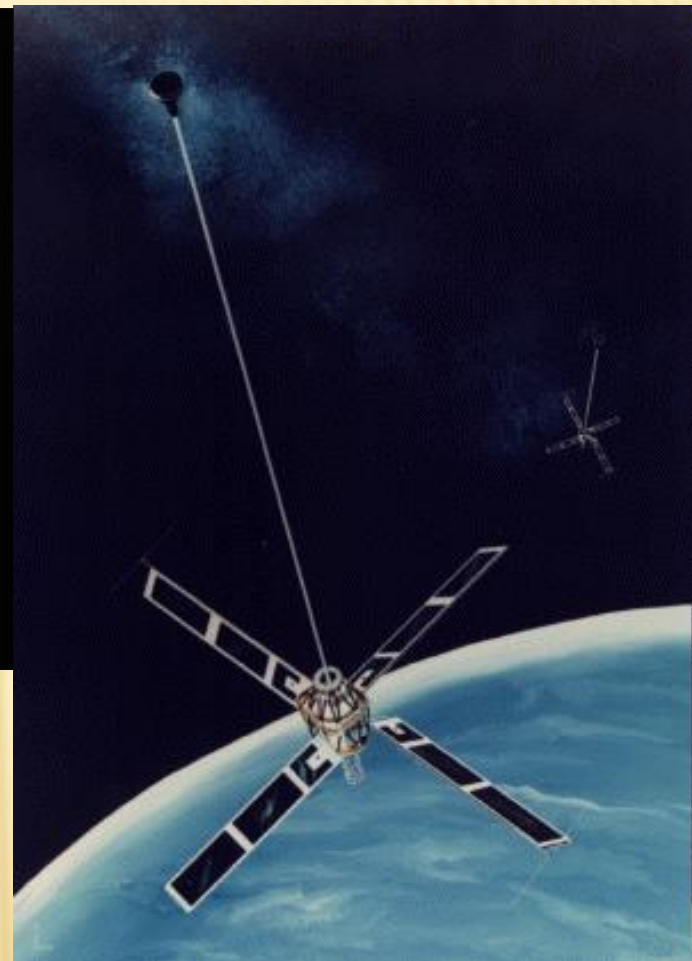
GLOBAL SATELLITE TRIANGULATION NETWORK
(BC-4)
1964-1973



**ECHO/PAGEOS BALLOON SATELLITE
TYPE PHOTOGRAPHED BY BC-4**



**BC-4 CAMERA PHOTOGRAPH
PAGEOS SATELLITE AGAINST THE STAR BACKGROUND**



U.S. NAVY NAVSAT TRANSIT SATELLITE “Doppler”

Prototype Launched (Failed) 1959

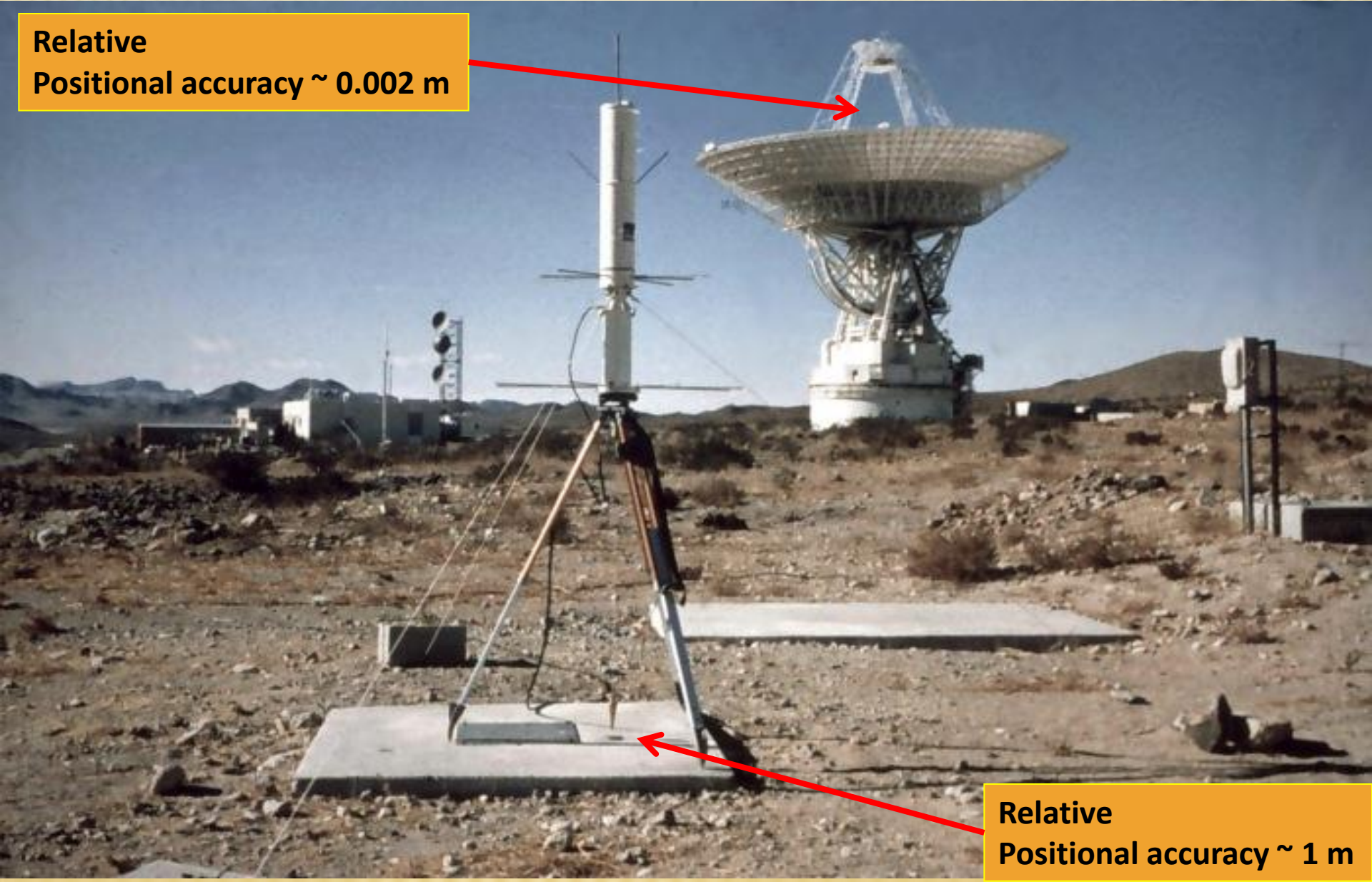
First Successful Test 1960

Operational 1964 (Military)

Civilian Access 1967

Transit Geceiver and VLBI

Relative
Positional accuracy ~ 0.002 m



Relative
Positional accuracy ~ 1 m

Global Positioning System



GPS Block I



GPS Block II



GPS Block III

- **February 22, 1978 - 1st NAVSTAR Satellite launched**
- **July 17, 1995 - System Fully Operational**
- **May 1, 2000 - Selective Availability turned off**
- **September 26, 2005 - L2C band added**
- **May 28, 2010 - First L5 Satellite added**
- **Mid 2015 – First Block III scheduled for launch**
- **2020? - 10-70 cm real-time accuracy!**

Macrometer V-1000 GPS Receiver

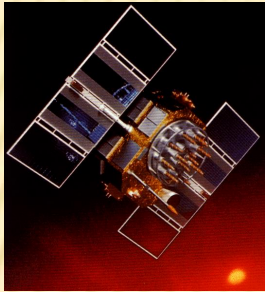
1982 ~ appox. \$250,000 each



Where are we now??



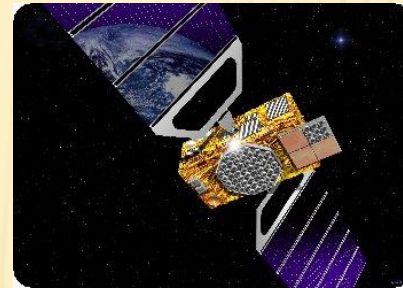
Global Navigation Satellite System



US - GPS



Russia - GLONASS



EU - Galileo



China – BeiDou

Four positioning and navigation systems

- **NAVSTAR/GPS – US (Currently 31)**
- **GLONASS – Russia (Currently 24)**
- **GALILEO – EU (Currently 4, 30 by 2019)**
 - **BEIDOU – China (30+ by 2020?)**



NGS Geodetic Tool Kit



on-line interactive computation of geodetic values

See the text version of an [article](#) about the NGS Geodetic Toolkit that appeared in the *Professional Surveyor* magazine, May 2003 Volume 23, Number 4

([See all the Professional Surveyor Articles about the NGS Geodetic Toolkit](#))

To learn more about a particular online program, click on its link for a description:

[DEFLEC99](#)

[DYNAMIC HT](#)

[G99SSS](#)

[GEOID99](#)

[GEOID03](#)

[USGG2003](#)

[HTDP](#)

[IGLD85](#)

[Inverse/Forward/Invers3D/Forwrd3D](#)

[LVL DH](#)

[Magnetic Declination](#)

[NADCON](#)

[NAVD 88 Modelled Gravity](#)

[Online Adjustment User Services](#)

[Online Adjustment Utilities User Services](#)

[OPUS](#)

[State Plane Coordinates](#)

[Surface Gravity Prediction](#)

[Tidal and Orthometric Elevations](#)

[U.S. National Grid](#)

[Universal Transverse Mercator Coordinates](#)

[VERTCON](#)

[XYZ Coordinate Conversion](#)

OR... Know what you want to do?

Select a function from this list:



National Spatial Reference System

North American Datum of 1983 (NAD 83) – Released 1986

North American Vertical Datum of 1988 (NAVD 88) – Released 1991

NAD 83 - First civilian datum designed to be consistent with space-based observations (GPS)

NAD 83 - First civilian datum to be best-fitting globally not locally

NAD 83 - First geodetic datum to be fully automated

First geodetic reference system to be available free from WWW

Only reference system to freely integrate data from outside sources

GEODETIC DATUMS

HORIZONTAL

2-D (Latitude and Longitude)

U.S. Standard Datum, NAD 27, NAD 83 (1986)

Fixed and Stable - Coordinates seldom change



GEOMETRIC

3-D (Latitude, Longitude and Ellipsoid Height)

Fixed and Stable - Coordinates seldom change

NAD 83 (“*HARN*”), NAD 83 (CORS96), NAD 83 (2007), NAD 83 (2011)



4-D (Latitude, Longitude, Ellipsoid Height, Velocities) Coordinates change with time
(e.g. ITRF00, IGS08)

VERTICAL

1-D (Orthometric Height) (Leveling constrained to 1 or more long-term tide stations)
(e.g. 1st General Adjustment, NGVD 29, NAVD 88, PRVD 02 etc.)



GEOPOTENTIAL

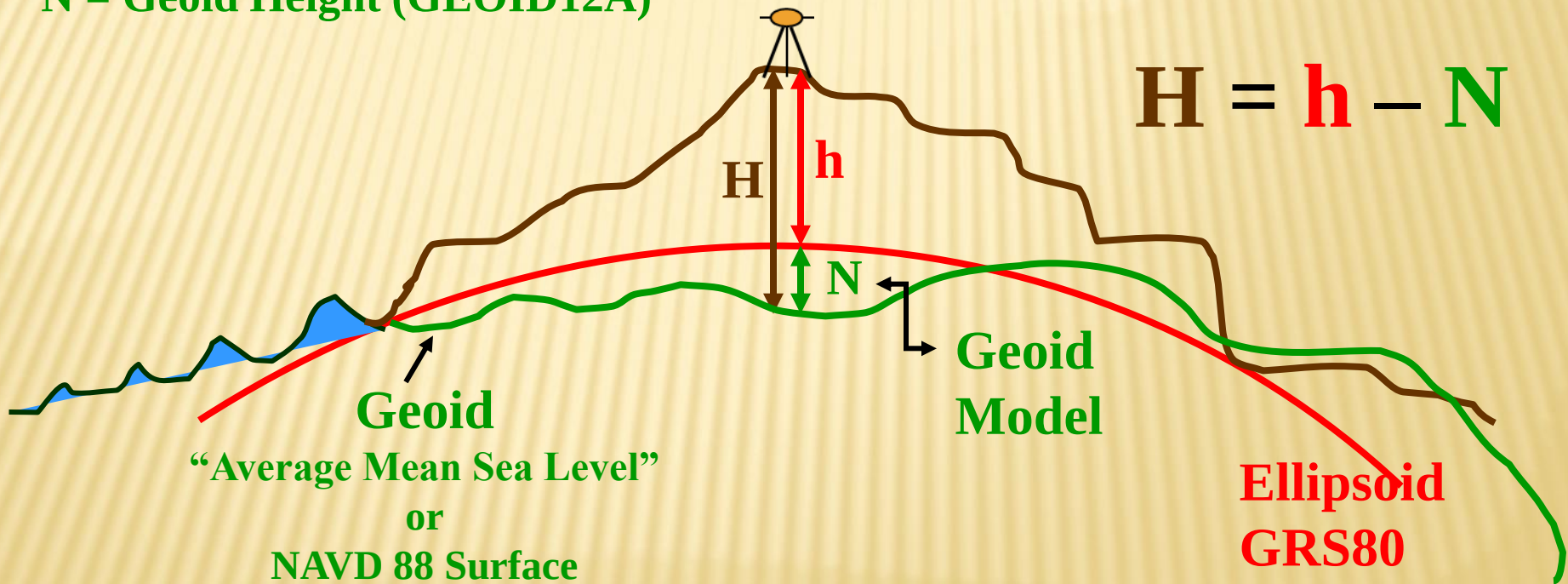
1-D (Orthometric Height) (Realized by GNSS + High Accuracy Gravimetric Geoid Model – e.g. GRAV-D)

ELLIPSOID – GEOID RELATIONSHIP

H = Orthometric Height (NAVD 88)

h = Ellipsoid Height (NAD 83 (2011))

N = Geoid Height (GEOID12A)



EARLY NAD 83 NETWORK PROBLEMS

NOT “GPSABLE”

POOR STATION ACCESSIBILITY

IRREGULARLY SPACED

POSITIONAL ACCURACY

**HIGH PRECISION GPS NETWORK (HPGN)
HIGH ACCURACY REFERENCE NETWORK (HARN)
1989 - 1997**

“GPSABLE”

Clear Horizons for Satellite Signal Acquisition

EASY ACCESSIBILITY

Few Special Vehicle or Property Entrance Requirements

REGULARLY SPACED

Always within 20-100 Km

HIGH ACCURACY

A-Order (5 mm + 1:10,000,000) (3 5.5 hr sessions)

B-Order (8mm + 1:1,000,000) (2 5.5 hr sessions)

MARYLAND OBSERVED - 1991

FEDERAL & COOPERATIVE BASE NETWORKS (FBN/CBN)

1997 -2004

MORE STATE PARTNERSHIPS

**REMOVE DISTORTIONS IN EARLY HARNS
(3-10 CM)**

ENSURE CONNETIONS TO CORS

**IMPROVE ELLIPSOID HEIGHT ACCURACY
(Not more than 2 cm)**

MARYLAND – 2000

International Gold Standard

International Earth Rotation and Reference System Service (IERS)



**Established 1987
Office in Paris, France**

**Produces the International Terrestrial Reference System
And
International Terrestrial Reference Frame**

First ITRF – 1988

Current ITRF – 2008

Next ITRF – 2013 (Release late 2014?)

IERS Four Geodetic Services

International DORIS Service



International GNSS Service

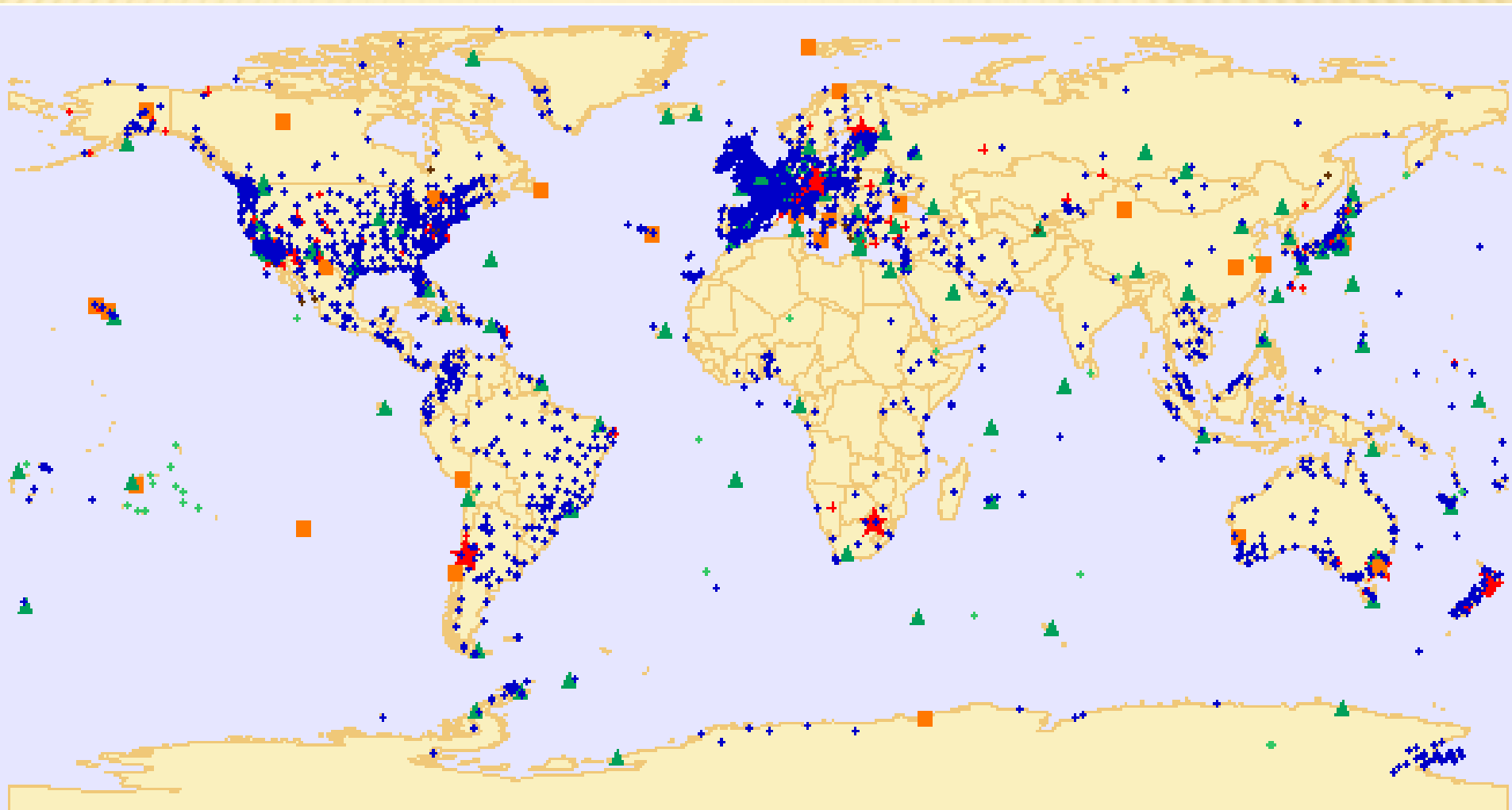


International Laser Ranging Service



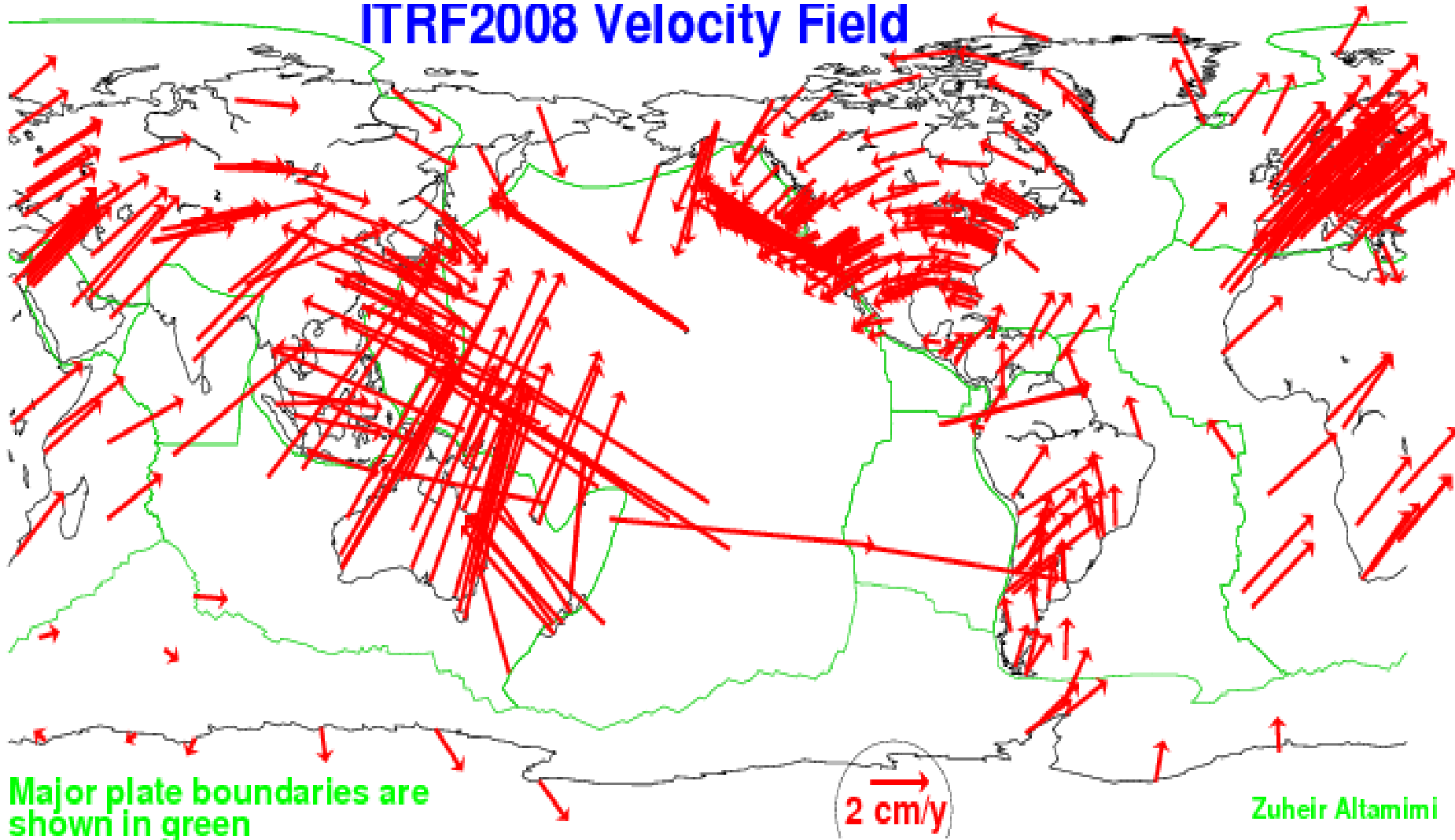
International VLBI Service

IERS NETWORK



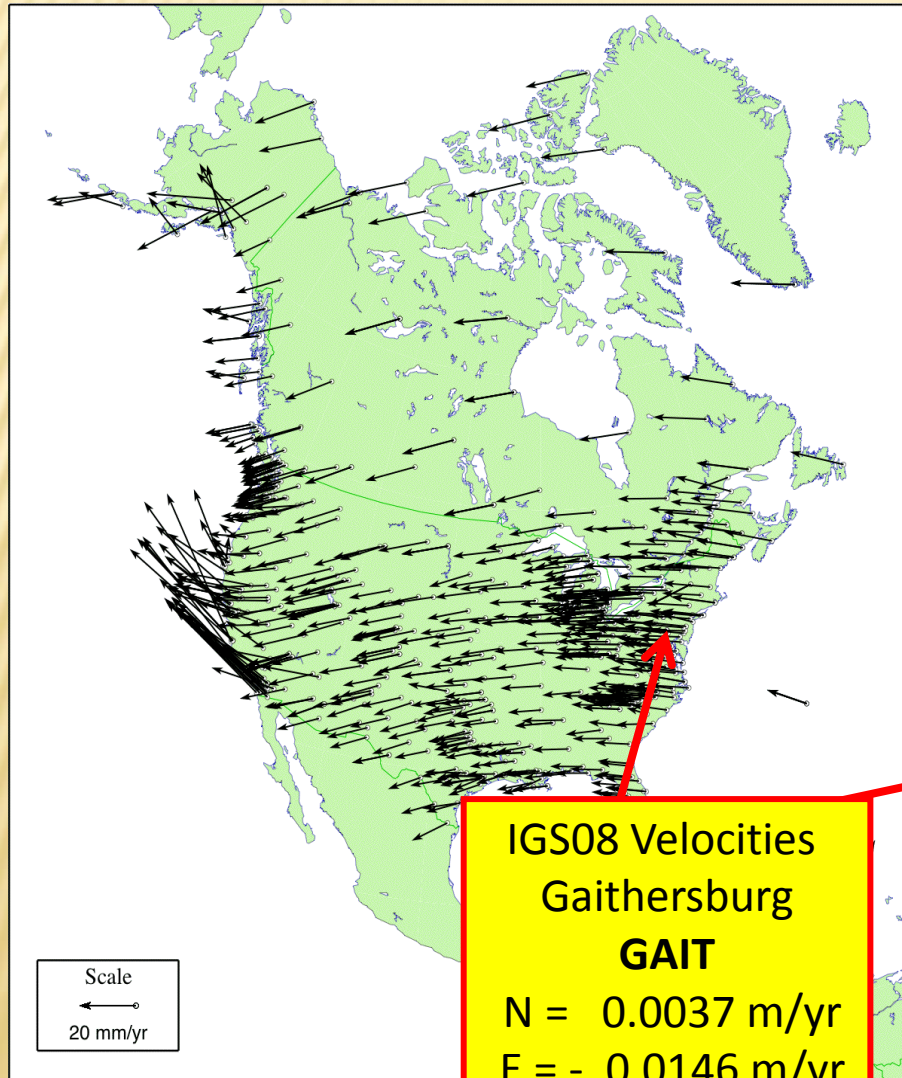
Tectonic Plate Velocities

ITRF2008 Velocity Field

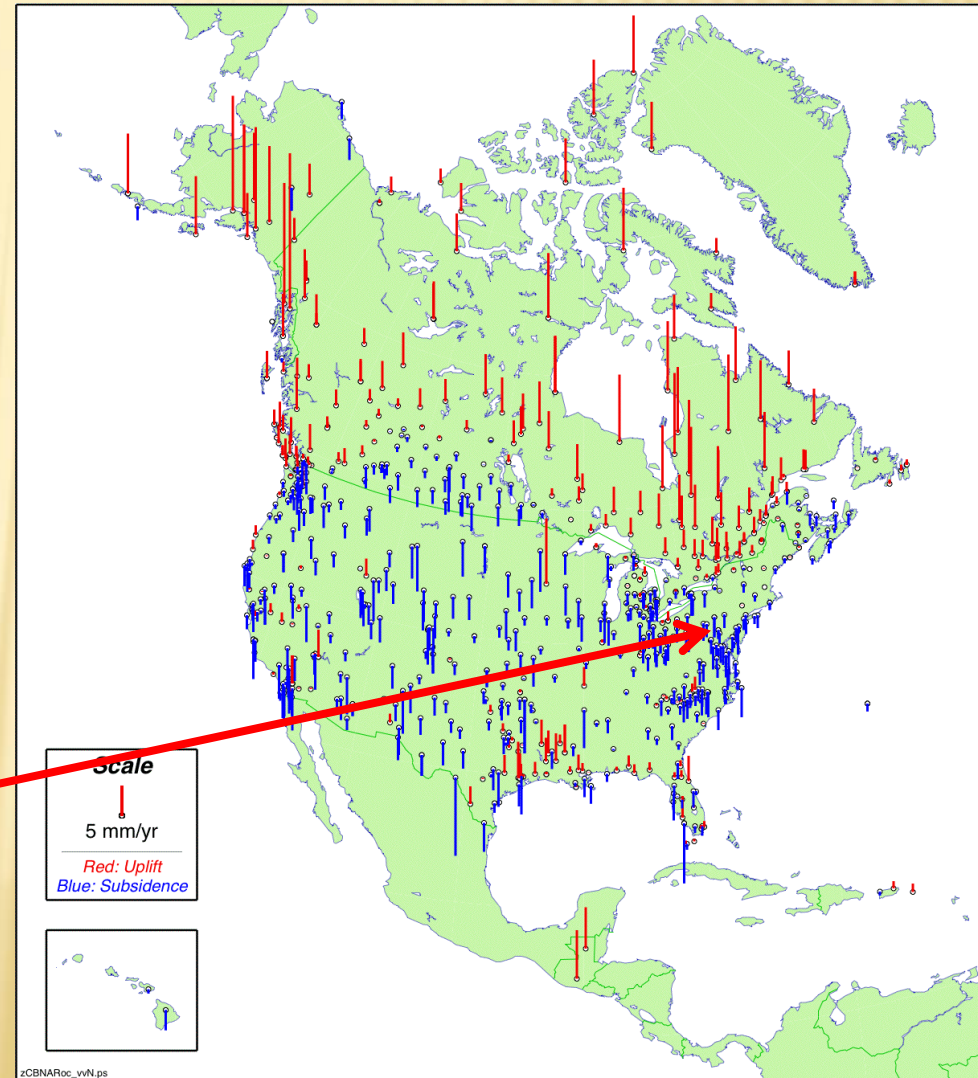


Tectonic Plate Velocities

Horizontal



Vertical



IGS08 is the GNSS component of the ITRF08

They can be considered to be equivalent

GAITHERSBURG (GAIT), MARYLAND

Antenna Reference Point(ARP): GAITHERSBURG CORS ARP

PID = AF9522

IGS08 POSITION (EPOCH 2005.0)

Computed in Aug 2011 using data through gpswk 1631.

X =	1095790.109 m	latitude	=	39 08 02.36993 N
Y =	-4831326.579 m	longitude	=	077 13 15.53251 W
Z =	4003934.292 m	ellipsoid height	=	107.636 m

IGS08 VELOCITY

Computed in Aug 2011 using data through gpswk 1631.

VX =	-0.0148 m/yr	northward	=	0.0037 m/yr
VY =	-0.0006 m/yr	eastward	=	-0.0146 m/yr
VZ =	0.0026 m/yr	upward	=	-0.0004 m/yr

NAD_83 (2011) POSITION (EPOCH 2010.0)

Transformed from IGS08 (epoch 2005.0) position in Aug 2011.

X =	1095790.791 m	latitude	=	39 08 02.34022 N
Y =	-4831328.033 m	longitude	=	077 13 15.51820 W
Z =	4003934.388 m	ellipsoid height	=	108.914 m

NAD_83 (2011) VELOCITY

Transformed from IGS08 velocity in Aug 2011.

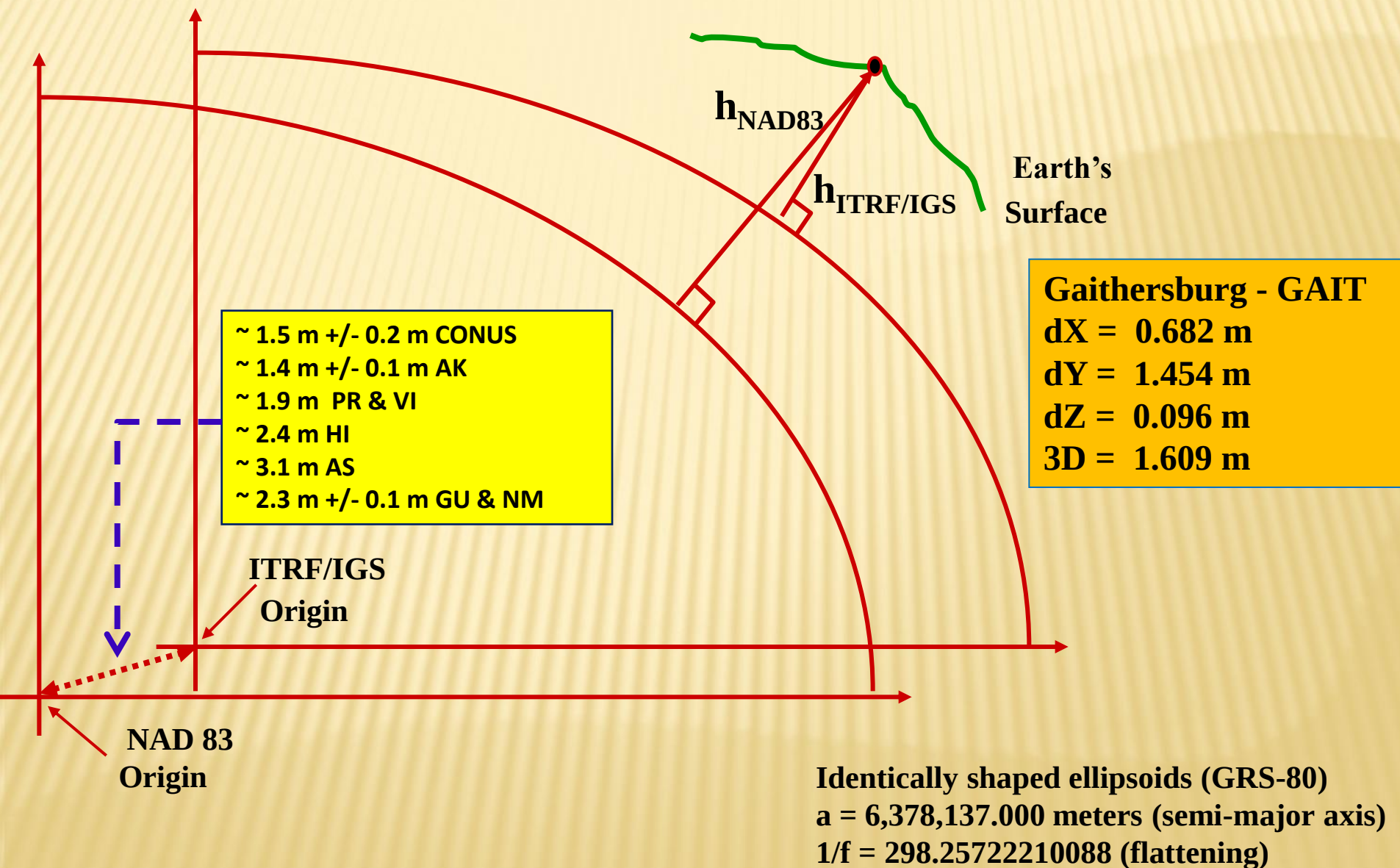
VX =	0.0018 m/yr	northward	=	-0.0009 m/yr
VY =	0.0009 m/yr	eastward	=	0.0020 m/yr
VZ =	-0.0016 m/yr	upward	=	-0.0014 m/yr

IGS08 - NAD 83(2011)

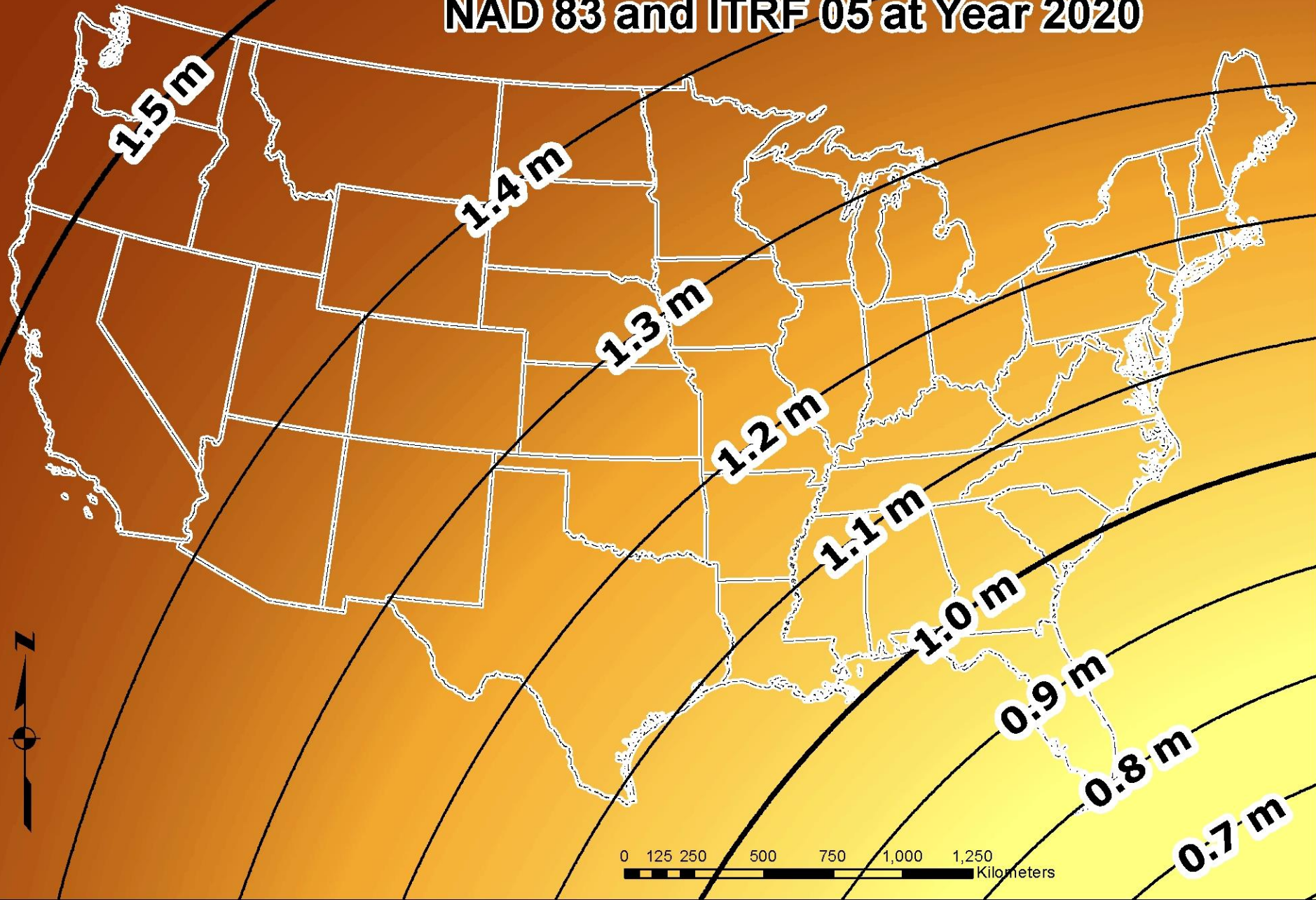
ΔHoriz = 0.979 m

ΔEht = 1.278 m

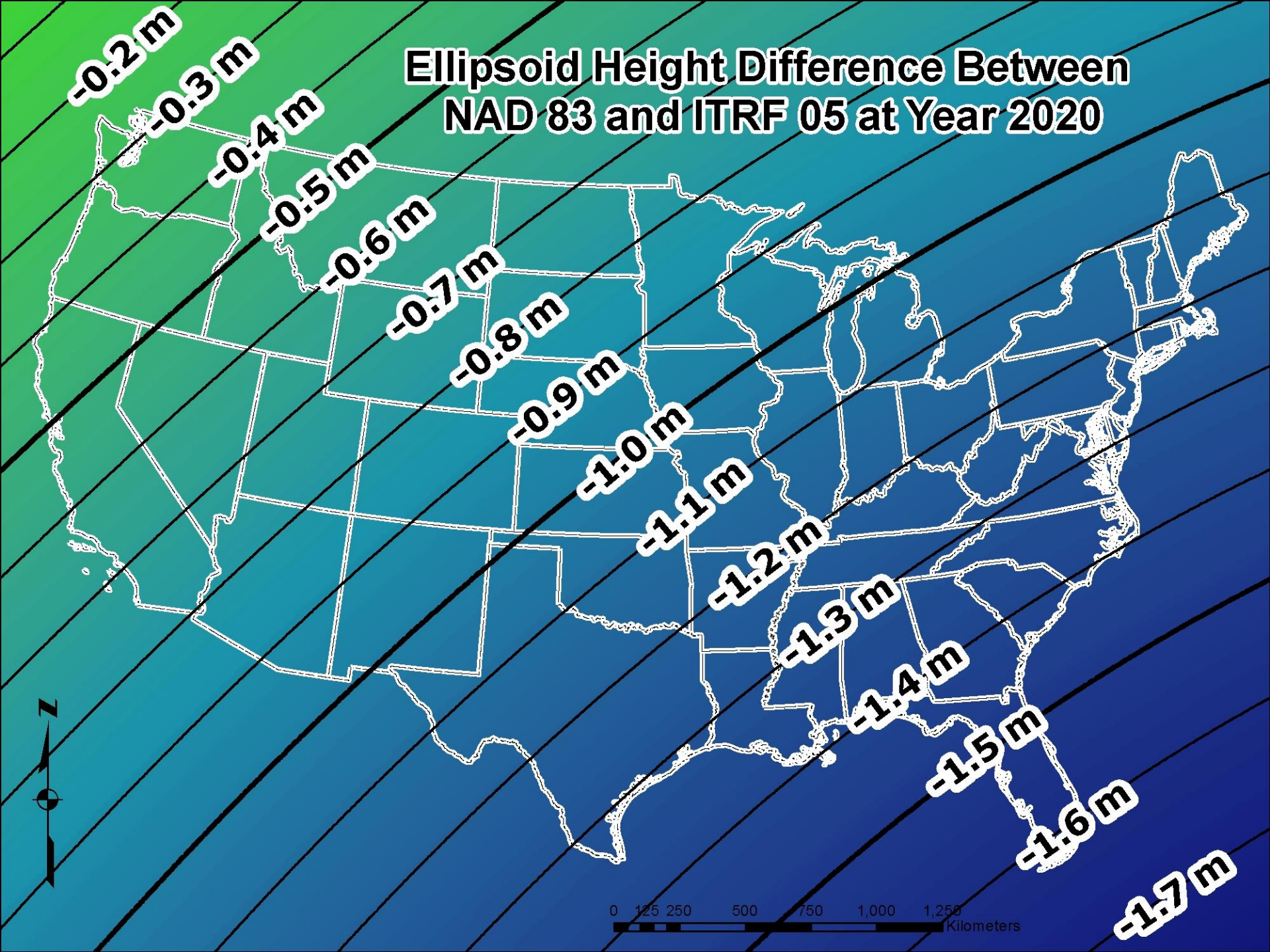
Simplified Concept of NAD 83 vs. ITRF/IGS



Horizontal Position Difference Between NAD 83 and ITRF 05 at Year 2020



Ellipsoid Height Difference Between NAD 83 and ITRF 05 at Year 2020



THE GEOID

An equipotential surface to which gravity is normal and most closely approximates Mean Sea Level over the entire Earth.

So What Do We have??

Types and Uses of Geoid Height Models

Gravimetric (or Gravity) Geoid Height Models

(e.g. USGG2012, USGG2009)

Defined by gravity data crossing the geoid

Refined by terrain models (DEM's)

Scientific and engineering applications

Composite (or Hybrid) Geoid Height Models

(e.g. GEOID12A, GEOID09)

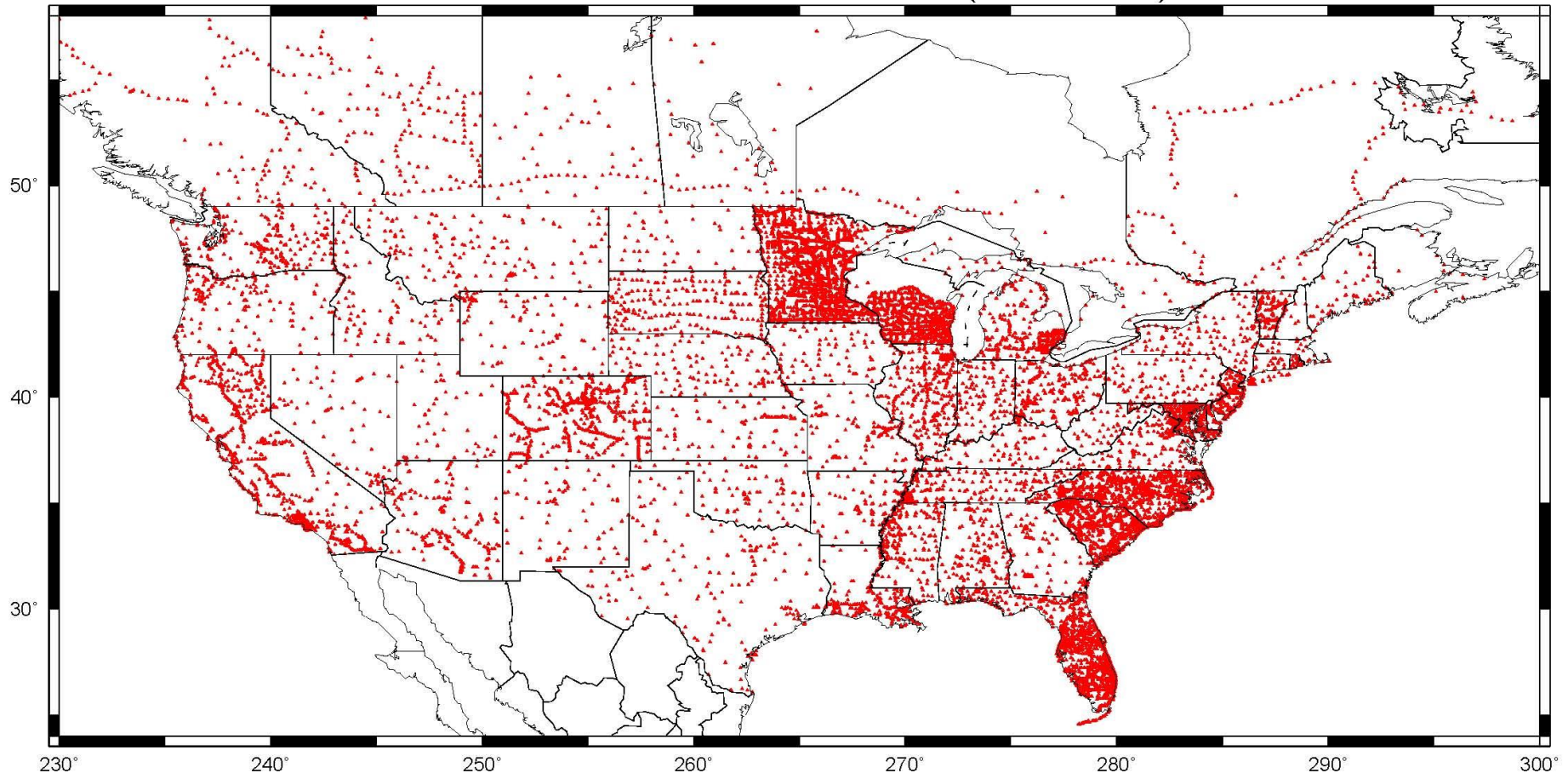
Starts with gravimetric geoid

Warped to fit available GPSBM control data

Defined by legislated ellipsoid (NAD 83) and local vertical datum (NAVD 88, PRVD02, etc.)

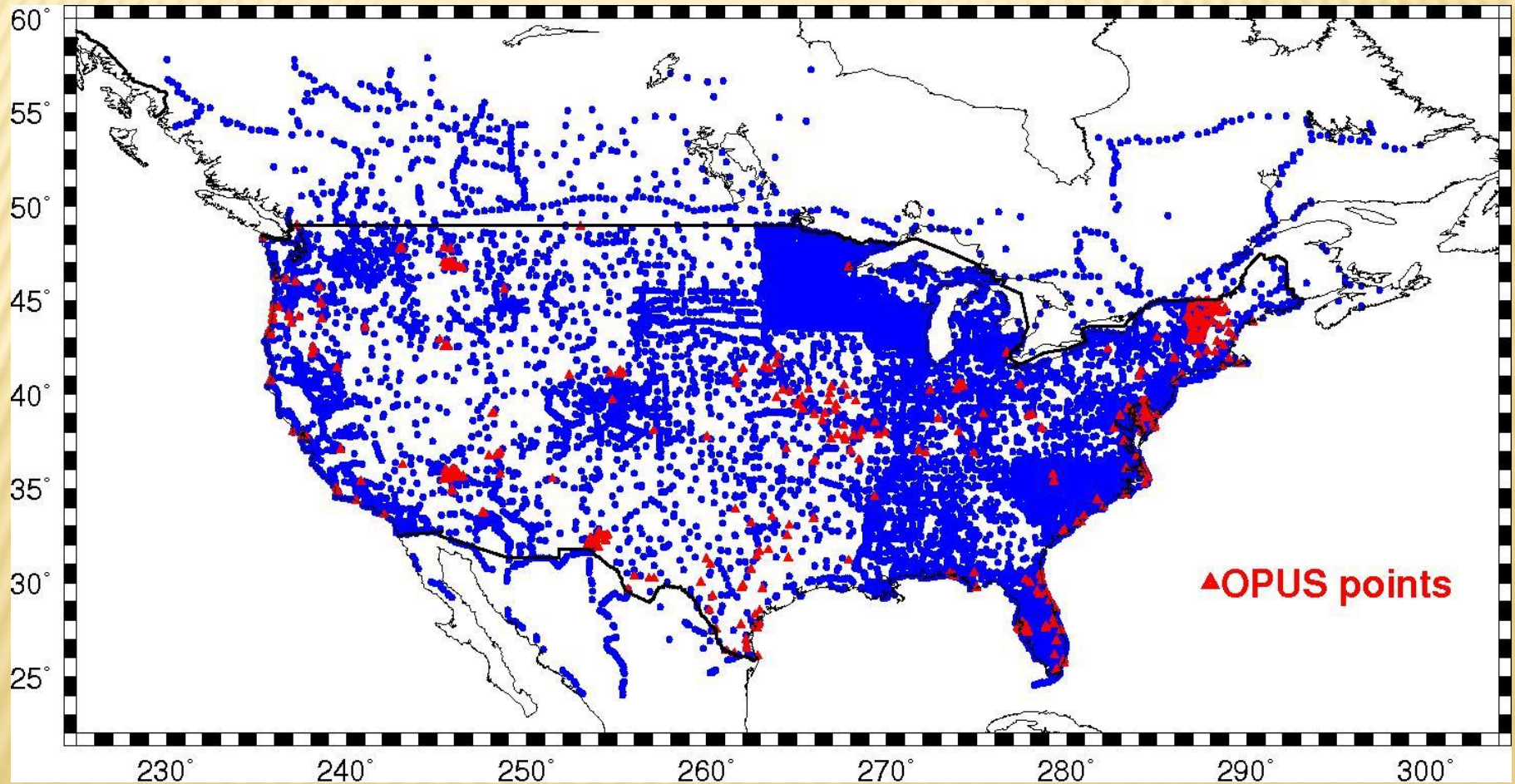
May be statutory for some surveying & mapping applications

GPS Bench Marks Used for GEOID09 (18972 Points)



GPSBM1999:	6,169 total	0 Canada	STDEV 9.2 cm (2σ)
GPSBM2003:	14,185 total	579 Canada	STDEV 4.8 cm (2σ)
GPSBM2009:	18,291 total	576 Canada	STDEV 2.8 cm (2σ)

DISTRIBUTION OF GPSBM IN GEOID12A



What is a Vertical Datum?

- **Surface:** A surface of zero elevation to which heights are referred
- **Heights:** What type of heights will be determined above the zero elevation surface
- Vertical datum must have:
 - A **definition:** a set of constants
 - A **realization:** how you access it



"topographic map." Online Art.
Britannica Student Encyclopædia.
17 Dec. 2008
<<http://student.britannica.com/ebi/art-53199>>

NAVD 88: Current Vertical Datum



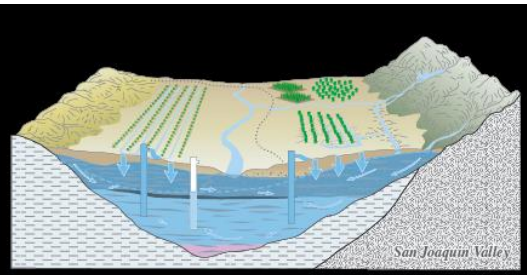
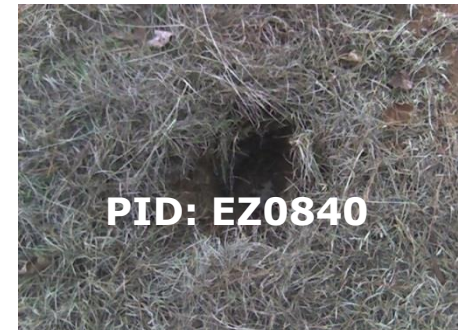
Father Point
Lighthouse, Quebec

NAVD 88: North American Vertical Datum of 1988

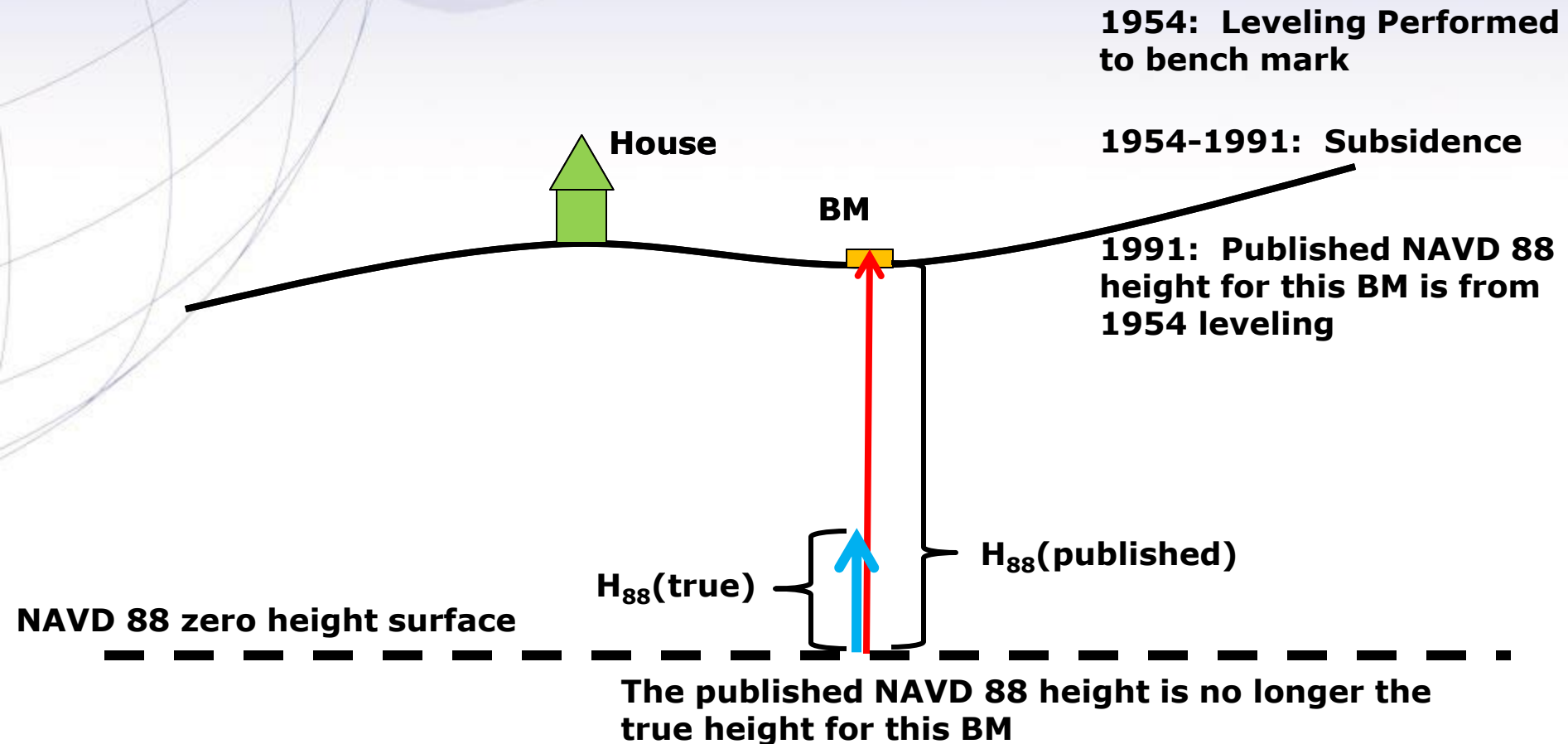
- The surface of equal gravity potential to which orthometric heights shall refer in the US
- ***How Defined:***
 - Massive leveling and gravity campaign across the country in the 1980's yielded measurements at >500,000 benchmarks
 - Minimally constrained adjustment of level/grav data, holding geopotential value fixed at one point: 6.271 meters (along the plumb line) below the geodetic mark at "Father Point/Rimouski" (NGSIDB PID TY5255)
- ***Realization:***
 - NAVD 88 is only defined at these benchmarks.

Bench Marks

- **NAVD 88 is defined at bench marks that:**
 - Were determined by leveling from a single point, allowing cross-country error build up
 - Are not always conveniently located
 - Disappear by the thousands every year
 - Are not funded for replacement
 - Are rarely re-checked for movement
 - Don't exist in most of Alaska



Subsidence and Bench Mark Height



Subsidence in the area of Chesapeake Bay

1973 Report by S. Holdhal and N. Morrison

Rates of Elevation
Change (mm/yr)

IGS08
Vertical Velocity at Selected CORS

CORB = - 0.0010

VAGP = - 0.0027

BACO = - 0.0032*

GODE = - 0.0011

GAIT = - 0.0004

ANP6 = - 0.0016

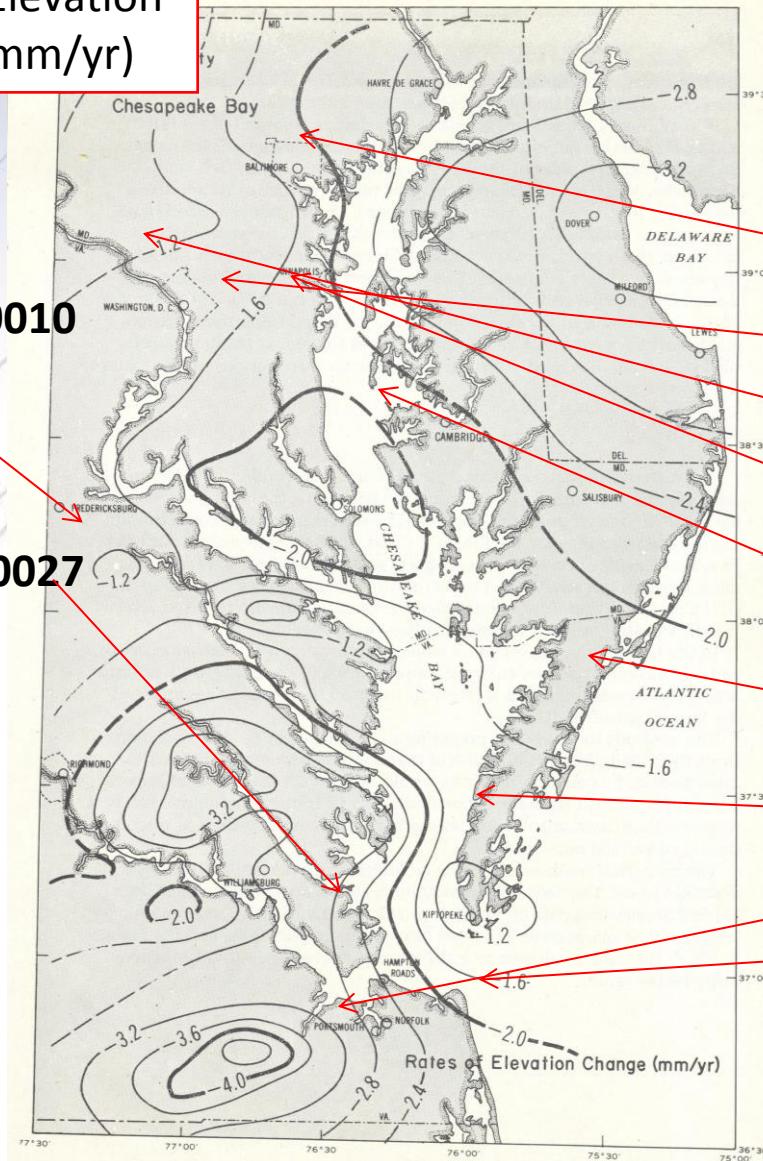
HNPT = - 0.0024

VAWI = - 0.0043*

VIMS = - 0.0034*

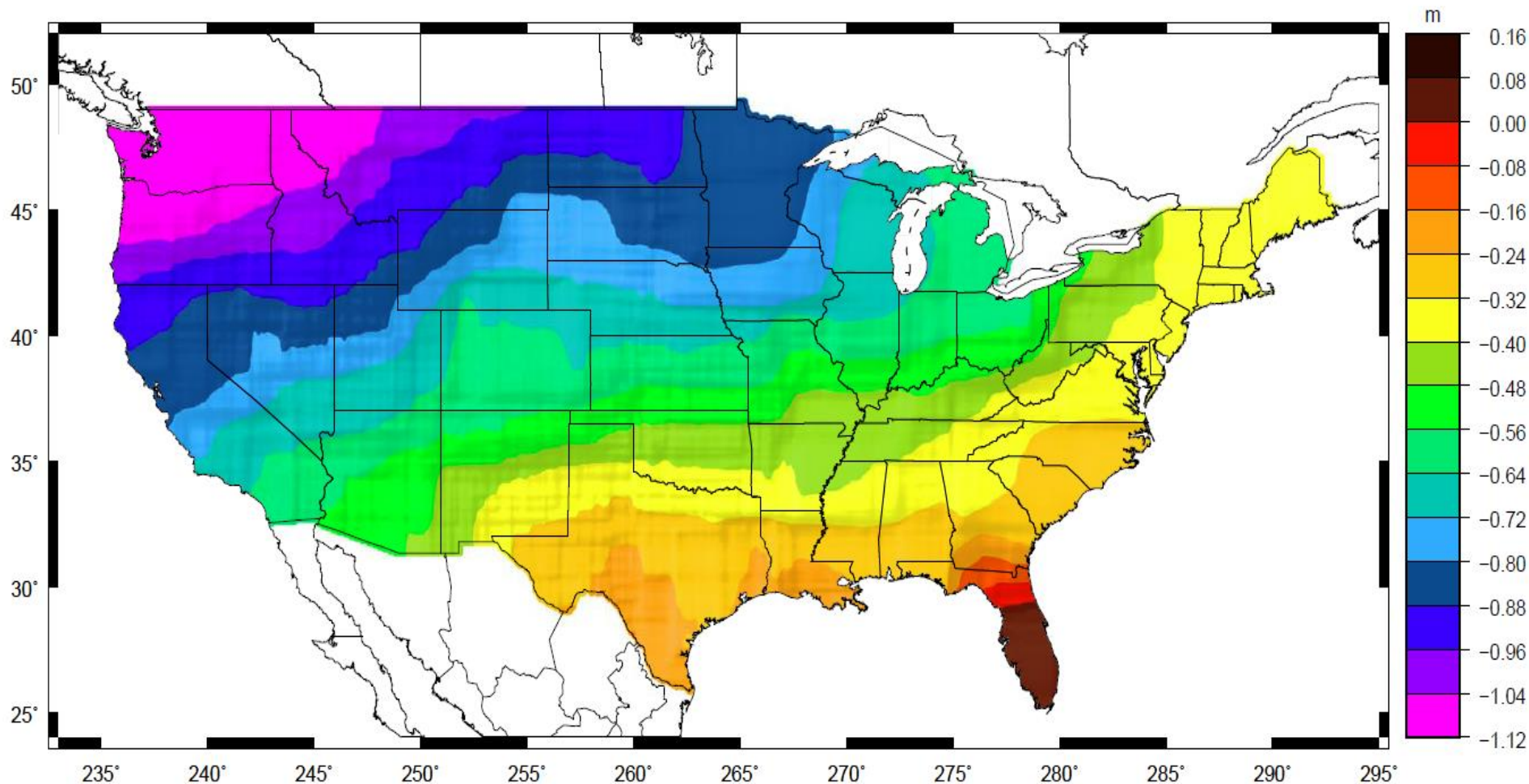
DRV6 = - 0.0033

COVX = - 0.0016



* = Differs by more than 1 mm from
1973 estimates

NAVD 88 Problems

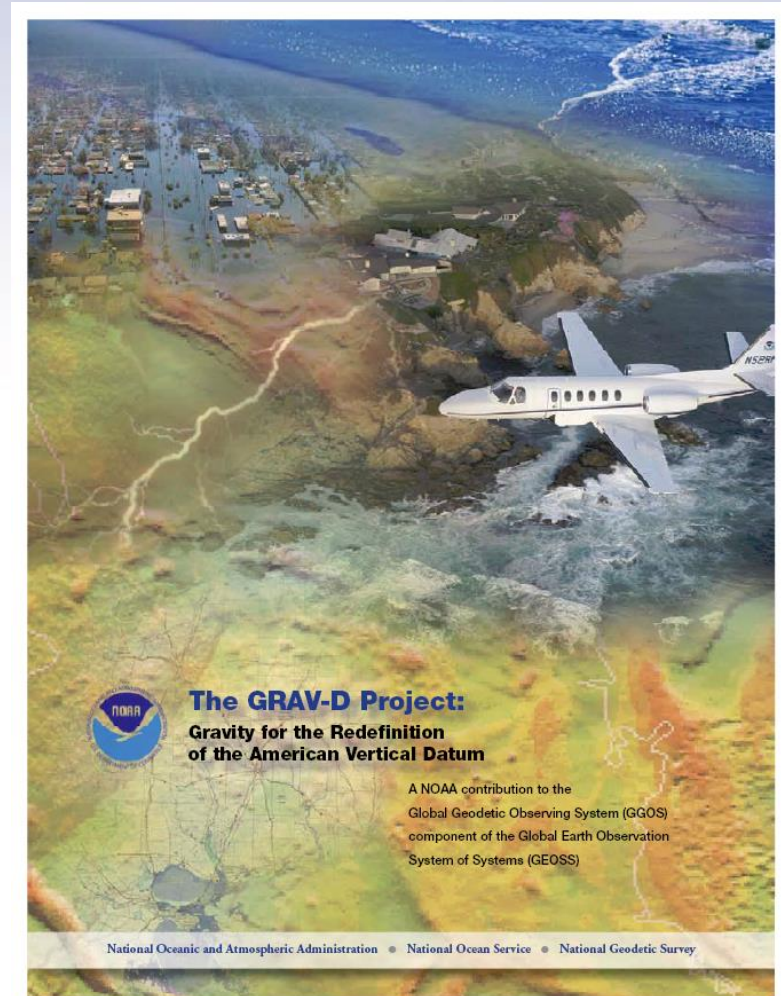


**Approximate mismatch between NAVD 88
(zero surface) and the global geoid (i.e. sea level)**

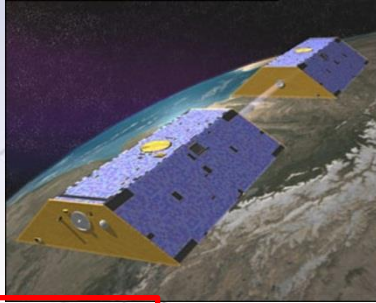
The GRAV-D Project

Gravity for the Redefinition of the American Vertical Datum

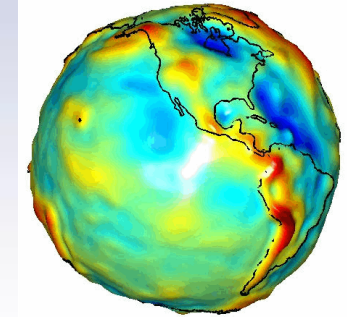
- **Official NGS policy as of Nov 14, 2007: release new geometric and vertical datums in 2022**
- **GRAV-D Project initiated to create a new gravimetric geoid to be basis of new vertical datum**
 - The realization of the new datum will be through GNSS receivers
- **GRAV-D Project**
 - Airborne Gravity Snapshot
 - Long-Term Change Monitored



Building a Gravity Field



Long Wavelengths
(≥ 250 km)



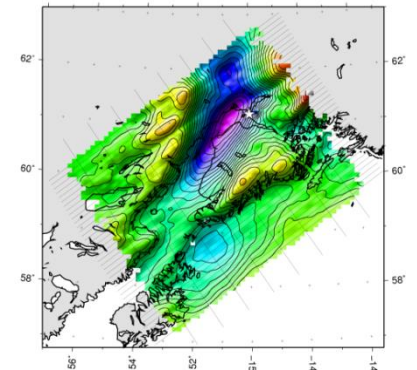
GRACE/GOCE/Satellite Altimetry

+



Intermediate Wavelengths
(500 km to 20 km)

Airborne Measurement



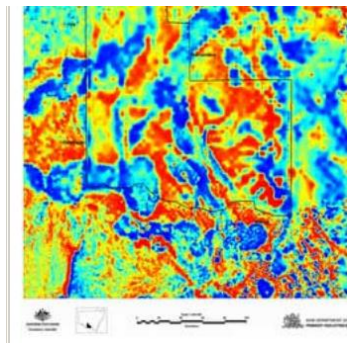
+

Short Wavelengths
(< 100 km)



Surface Measurement and

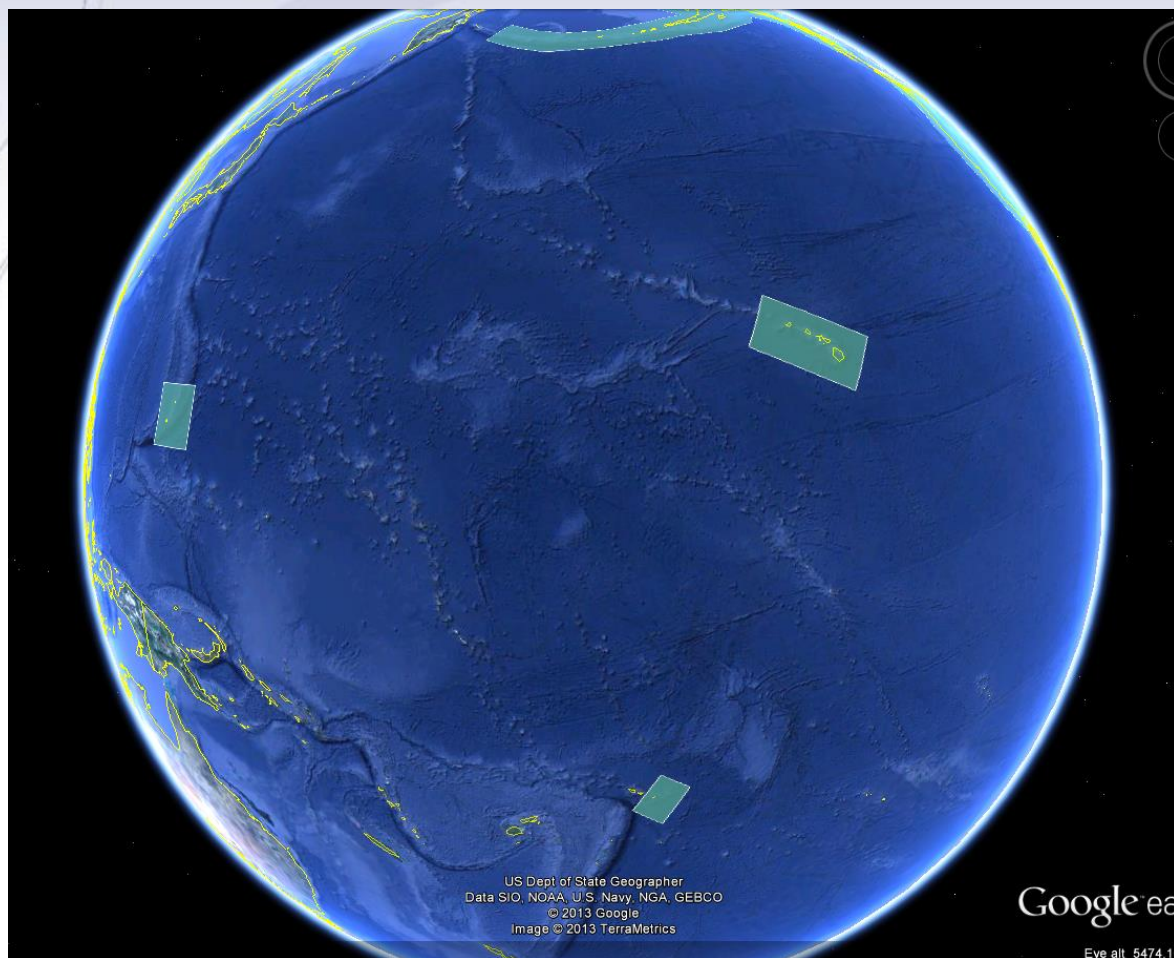
Predicted Gravity from Topography



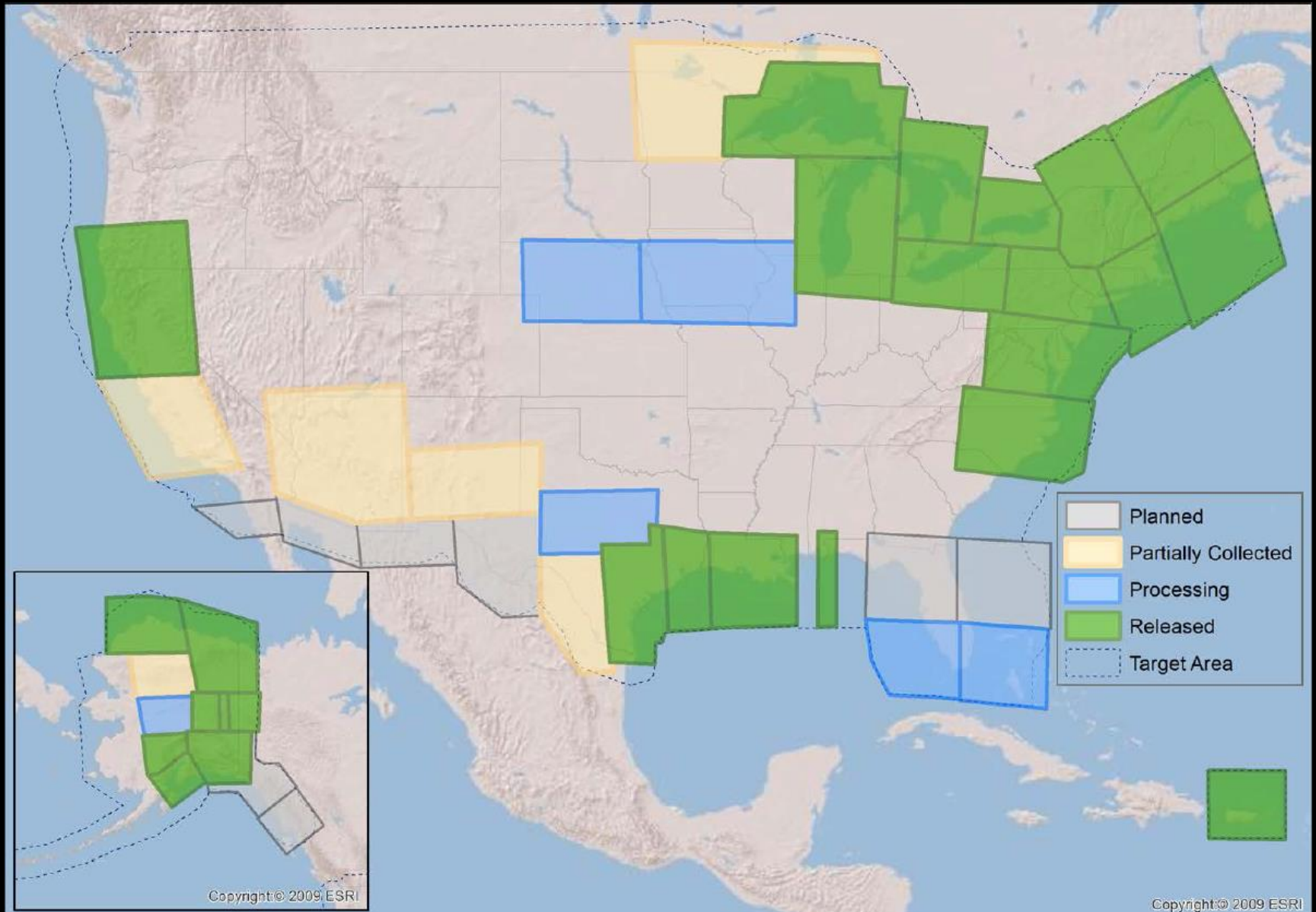
GRAV-D Coverage Area: CONUS & Alaska



GRAV-D Coverage Area: Pacific Islands



GRAV-D Status 10-1-14: 38%



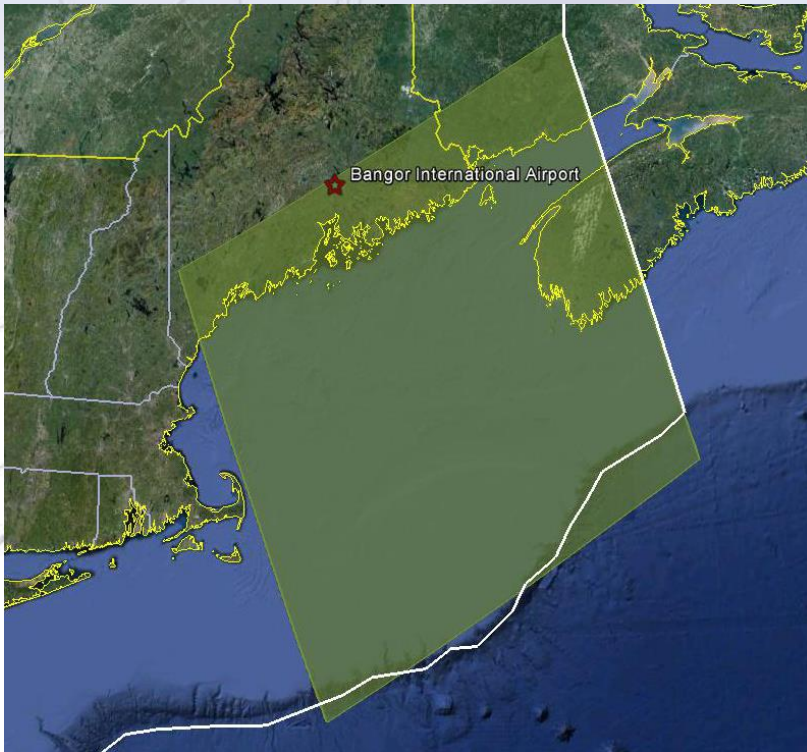
GPRA* Performance Metric For Airborne Surveys

FY09 Baseline	Targets vs Actual												
	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
6.14%	7.5%	12%	20%	28%	36%	44%	52%	60%	68%	76%	84%	92%	100% and Implement
6.14	7.8	14.7	23.9	31%	38%								

- **Measure:** Percentage of the U.S. and its territories with GRAV-D data available to support a 1 cm geoid supporting 2 cm orthometric heights.

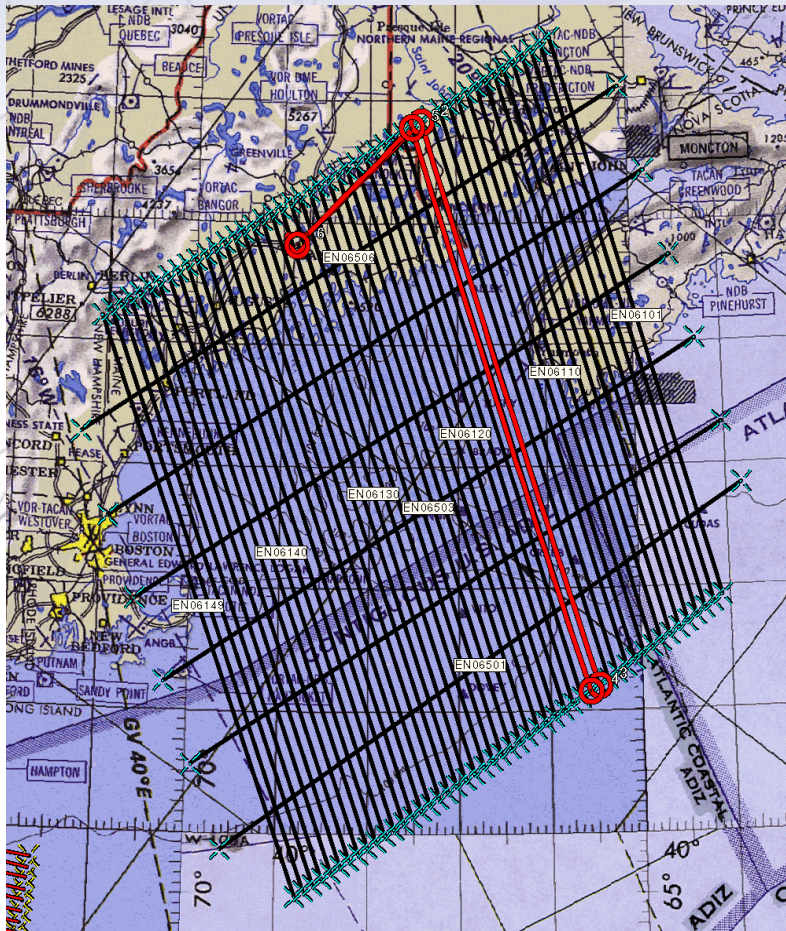
*GPRA = Government Performance and Results Act of 1993

The GRAV-D Airborne Operation: Survey Layout



- Layout rectangular survey 400 x 500 km
- Extends beyond the shelf break
- Block size will reflect the endurance of the aircraft

Survey Design



- Data lines spaced 10 km apart
- Cross lines spaced 60-80 km apart
- Flight altitude 20,000 ft
- Nominal speed 220-250 kts

GRAV-D Aircraft

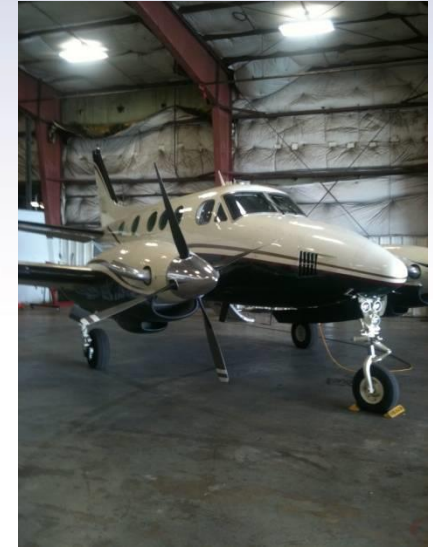
- DOI Bureau of Land Management
 - Pilatus PC-12
- Fugro
 - King Air E-90A
- Naval Research Lab
 - King Air RC-12
- Dynamic Aviation KA
 - King Air RC-12
- NOAA
 - Gulfstream Jet Prop
 - P-3 Orion Hurricane Hunter



Pilatus PC-12



King Air RC-12



King Air E-90A

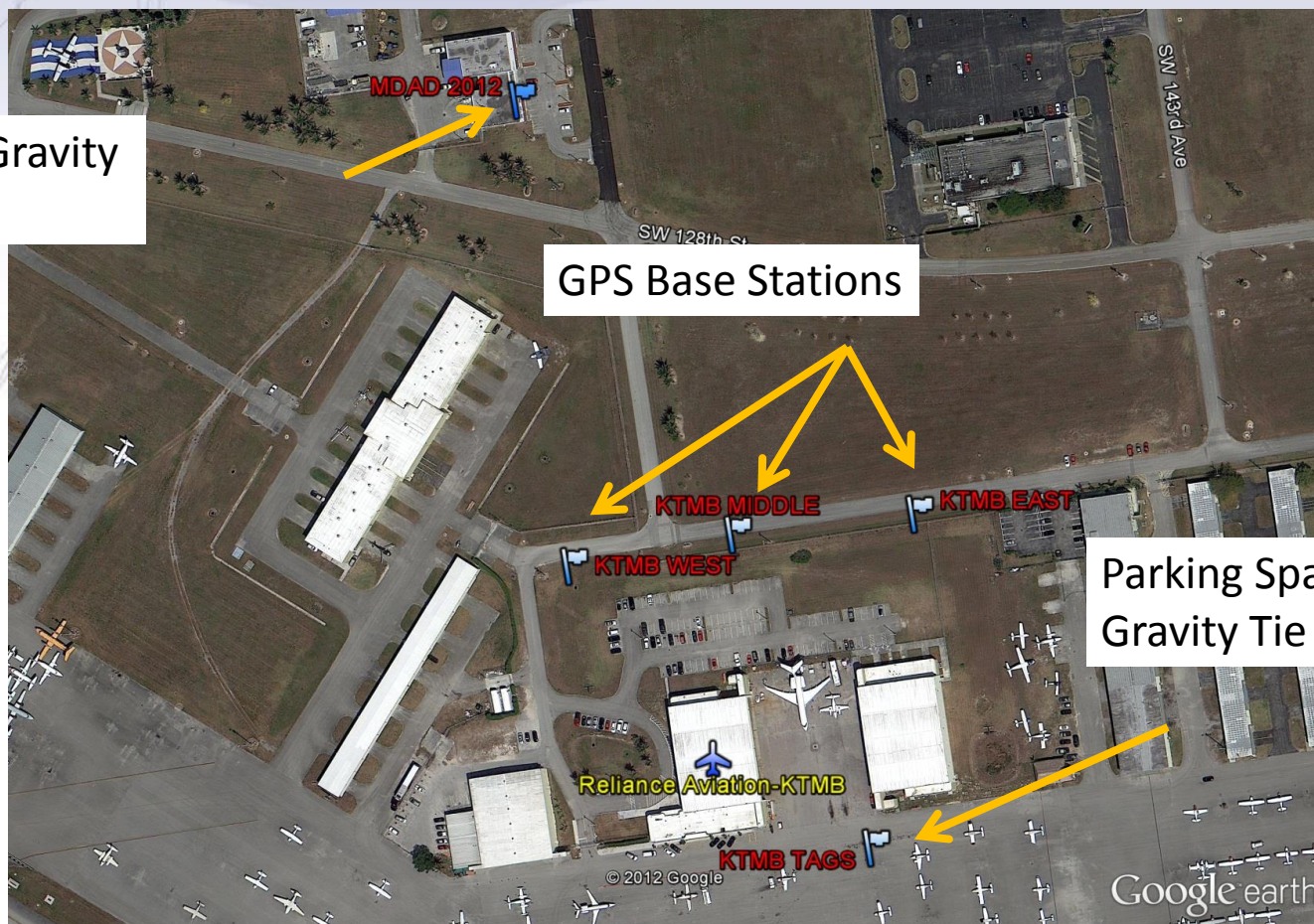


P-3 and Jet Prop

Reconnaissance Survey

Absolute Gravity
Station

GPS Base Stations



Parking Space
Gravity Tie

Reliance Aviation-KTMB

KTMB TAGS

Google earth

© 2012 Google

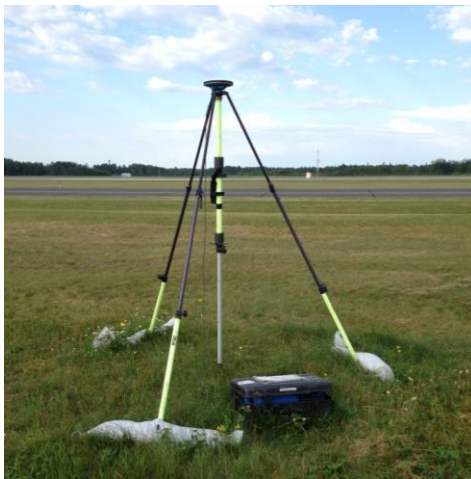
Gravity Tie and GPS Base Stations



Parking spot ID



A10 measurement



GPS Base Stations



Vertical gravity gradient

GRAV-D Instrumentation



Micro-g LaCoste
TAGS Gravimeter



NovAtel SPAN-SE
w/ Honeywell μ IRS IMU

- Both instruments include GNSS receivers
- SPAN system allows for tightly coupled GPS/IMU solutions

Instrument Installation



- Instrument suite installed
- Lever arm survey required
- Test flight performed



Data Collection and Field Data QC

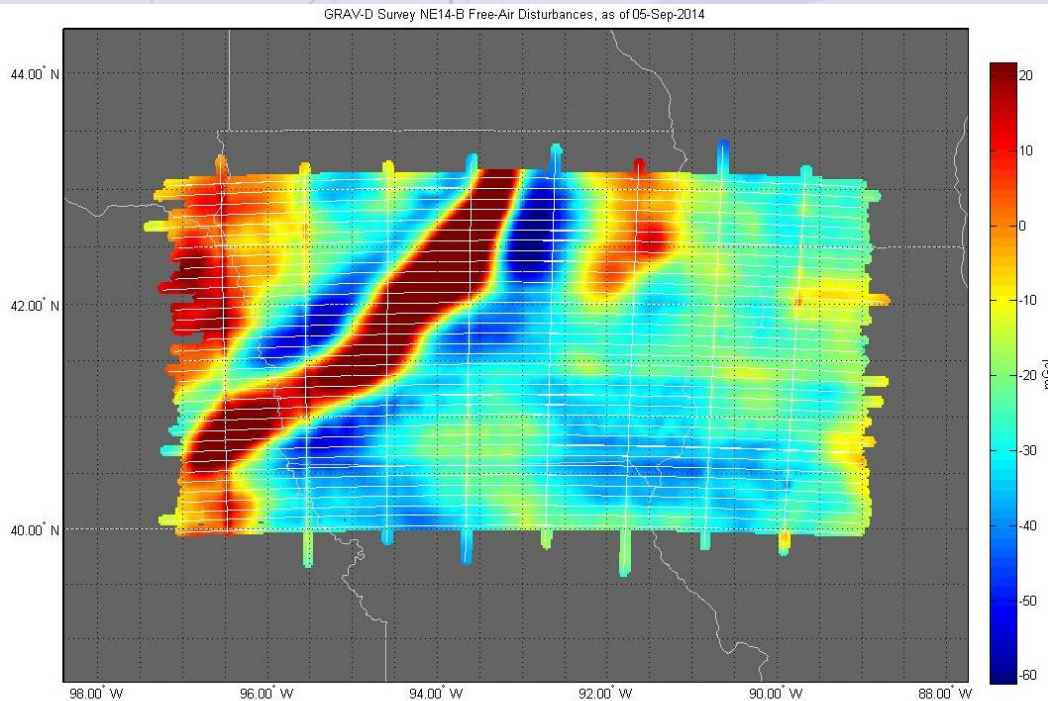
- Goal is two flights per day when/if:
 - Weather/atmosphere is calm (TAGS cannot tolerate turbulence)
 - Instruments and aircraft are in working order
 - Good GPS geometry
 - Military airspaces are not “hot”
 - We have the operators/pilots to support two flights per day

Data Collection and QC

- Data are evaluated to verify instrument performance and data quality

OBJECTIVE: Identify ASAP lines that must be reflow

Data Handling



Iowa Survey 2014

- Complete metadata logs daily and survey report written
- Ship the data back to HQ for final processing
- GPS/Gravity data reprocessed at HQ with precise orbits
- Released to the public via the GRAV-D website
- Released to the geoid team

GRAV-D Website

The screenshot shows a web browser window displaying the NOAA GRAV-D website. The browser's address bar shows the URL www.ngs.noaa.gov/GRAV-D/data_products.shtml. The website features a navigation menu with links to NGS Home, About NGS, Data & Imagery, Tools, Surveys, Science & Education, and a search bar. The main content area is titled "GRAV-D Google Map" and includes a section for "GRAV-D Data Products" with a description of available data and a link to the "General Airborne Gravity User Manual". A sidebar on the left lists various links, including "Data Products" which is highlighted with a red box. Below the sidebar, there are two small images: one showing a map of the United States and another showing a globe with the text "Save the Date". The main map area displays a map of North America with colored overlays indicating data collection status: green for available data and metadata, blue for data being processed, orange for data collection underway, and white for planned data collection. The map includes a scale bar and a coordinate display showing 78.2637, -148.3594.

GRAV-D Google Map
National Geodetic Survey

GRAV-D Data Products

Products will be posted as they are completed.
Available data may include airborne and terrestrial survey information, gravity data, and gravity-based geoids or datums. Click the block of interest to view general information and a link will appear if data are available.

GRAV-D Quick Links
Home
NACAG13 Absolute Gravimeter Comparison
Science Fundamentals
News Archive
Data Products
Publications
Meetings/Workshops
Informational Materials
Contact Us
Geoid Slope Validation Survey of 2011
Kinematic GPS Challenge

Download the GRAV-D Project Plan (.PDF):

Map Key - Airborne Gravity Data
Green: Available data and metadata
Blue: Data being processed
Orange: Data collection underway
White: Planned for data collection

78.2637, -148.3594
Map Satellite
Greenland
Iceland
Canada
United States
Mexico
North Pacific Ocean
North Atlantic Ocean

<http://www.ngs.noaa.gov/GRAV-D>

Creation of New Geoid

- Our surface gravity holdings will first be “cleaned” to repair or remove problem surveys
- A gravity field will be created from a blend of satellite, airborne, and corrected surface gravity data, plus gravity estimated from terrain
- Create the new geoid from this gravity field to be the basis of the new vertical datum slated for release in 2022

National Datum Modernization 2022

- Geometric Datum Rollout
 - New reference frame designed and implemented
 - *Realize* new datum with existing passive/active control, i.e. with an adjustment
- Vertical (Geopotential) Datum Rollout
 - Definition of W_0 as new datum reference surface
 - Gravimetric geoid with overall accuracy of 1 cm
 - *Realize* orthometric heights via GNSS receivers

Orthometric Heights from OPUS

Make geoid-based orthometric heights available via OPUS (NGS' Online Positioning User Service)

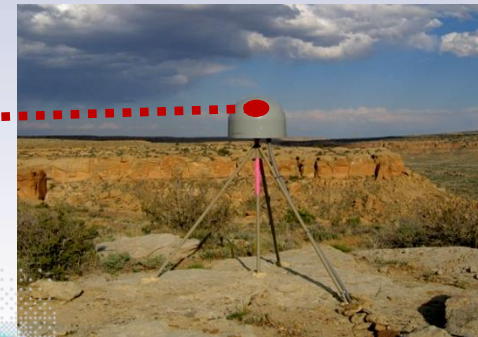
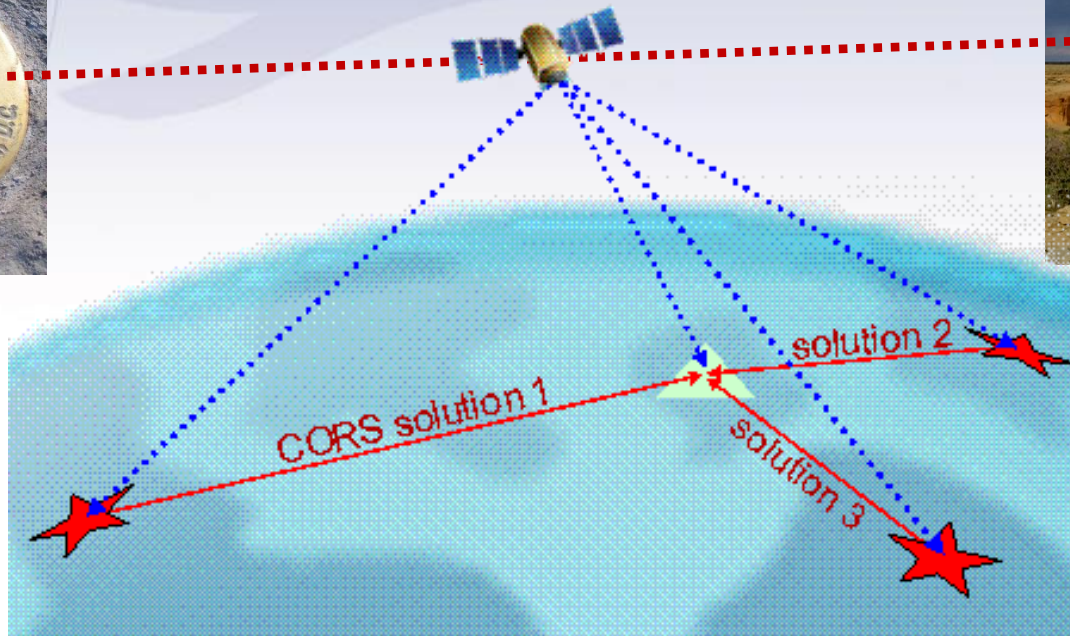
— Done, in extended output

**** Orthometric Heights Above Future Geopotential Datum.**

Prototype orthometric heights are now being made available as a precursor to the completion of GRAV-D and the replacement of NAVD 88 with a new geopotential reference system. The following height reflects the current best estimate of the true orthometric height, based on the existing gravimetric geoid model. This height is subject to change as data and modeling for the gravimetric geoid change throughout the lifetime of the GRAV-D project, or as new realizations of the ITRF are adopted. However, at the completion of GRAV-D, these heights will supersede the NAVD 88 heights

APPROX ORTHO HGT: 5.862 (m) [PROTOTYPE (Computed using USGG2012,GRS80,IGS08)]

Online Positioning User Service (OPUS)



- >15 min of L1/L2 GPS data >>> www.ngs.noaa.gov/OPUS
- Processed automatically on NGS computers
- Solution via email - in minutes

Fast, easy, consistent access to NSRS



National Geodetic Survey

Search



Contact OPUS

(OPTIONS)

OPUS-RS or OPUS-Static
(15 min-2 hr) (2-48 hr)

e-mail

GPS file

antenna

antenna height

[illegible][illegible]

Sample Solutions

search.

Agreement on W_0 Value

Agreement: The U.S. National Geodetic Survey and The Canadian Geodetic Survey

March 14, 2012

The U.S. National Geodetic Survey and Natural Resources Canada's Geodetic Survey Division, via conference call held 2012/02/17, agree:

- To **define** the common (a unique) vertical datum for the United States of America (USA) and Canada (CA) through use of an equipotential surface, realized through one commonly (jointly) computed geoid model, corresponding to the mean coastal sea level for North America by 2022. Adoption is subject to National decisions;
- To **compute** the potential W_0 of this equipotential surface using Global Positioning System (GPS) data on tidal benchmarks, by April 1, 2012 and to **use** this value, for the realization of geoid models in the USA and CA until 2022;
- To **maintain** this equipotential surface as one option to adopt as the vertical datum even if this surface diverges (departs) from the true mean coastal sea level for (around) North America over time;
- To **monitor** differences between the above-mentioned equipotential surface and the mean sea level via Global Navigation Satellite Systems (GNSS) on tidal benchmarks, altimetry or other means as required;
- To **provide** to the public, deformational velocities ($N\text{-dot}$) of the equipotential surface W_0 ;
- To **collaborate** in the realization of geoid models, through the sharing of data and related information;
- To **compute** updated geoid models and geoid deformation models with improved realizations as needed;
- To **inform** each other when large discrepancies (outside 95% confidence region) are found in overlapping regions; and
- To **choose** a threshold value (in alignment with both stakeholder needs and scientific integrity) in 2022, between predicted (modeled) geoid change and true geoid change (including deformation and sea level change) which will warrant new realization of the vertical datum.


 Denis Hains
 Director
 Geodetic Survey Division
 Canada Centre for Remote Sensing
 Natural Resources Canada
 Ressources naturelles Canada


 Juliana P. Blackwell
 Director
 National Geodetic Survey



Entente: National Geodetic Survey des États-Unis et les Levés géodésiques du Canada

14 mars, 2012

Le National Geodetic Survey des États-Unis et la Division des levés géodésiques du ministère des Ressources naturelles du Canada, par un appel conférence tenu le 2012/02/17, se sont entendus :

- À **définir** un datum vertical commun (unique) pour les États-Unis d'Amérique (USA) et le Canada (CA) par l'entremise d'une surface équipotentielle réalisée par un modèle du géoïde calculé en commun (ensemble), correspondant au niveau moyen des mers le long des côtes de l'Amérique du Nord par 2022. L'adoption est sujette aux décisions nationales;
- À **calculer** le potentiel W_0 de cette surface équipotentielle par mesures du Système de positionnement mondial (GPS) à des marégraphes avant le 1^{er} avril 2012 et à **utiliser** cette valeur pour la réalisation des modèles du géoïde des USA et du CA jusqu'en 2022;
- À **maintenir** cette surface équipotentielle comme une option pour l'adoption d'un datum vertical même si cette surface diverge (s'écarte), avec le temps, du véritable niveau moyen des mers de (entourant) l'Amérique du Nord.
- À **surveiller** la différence entre la surface équipotentielle mentionnée ci-haut et le niveau moyen des mers par mesures des Systèmes mondiaux de navigation par satellites (GNSS) à des marégraphes, par altimétrie et par autres moyens requis;
- À **fournir** au public des vitesses ($N\text{-dot}$) de déformation de la surface équipotentielle W_0 ;
- À **collaborer** à la réalisation des modèles du géoïde en partageant des données et l'information reliée;
- À **calculer** des mises-à-jour des modèles du géoïde et de déformation au besoin;
- À **s'informer** mutuellement des écarts importants (à l'extérieur d'une marge de confiance de 95%) retrouvés en régions chevauchantes;
- À **choisir** une valeur seuil (cadrant avec les besoins des utilisateurs et scientifiquement rigoureuse) en 2022 entre les changements prédits et réels du géoïde (incluant sa déformation et le changement du niveau moyen des mers) qui justifieront une nouvelle réalisation du datum vertical.


 Denis Hains
 Directeur
 Division des levés géodésiques
 Centre canadien de télédétection


 Ressources naturelles Canada
 Natural Resources Canada
 Canada


 Juliana P. Blackwell
 Directrice
 National Geodetic Survey



Experimental Models

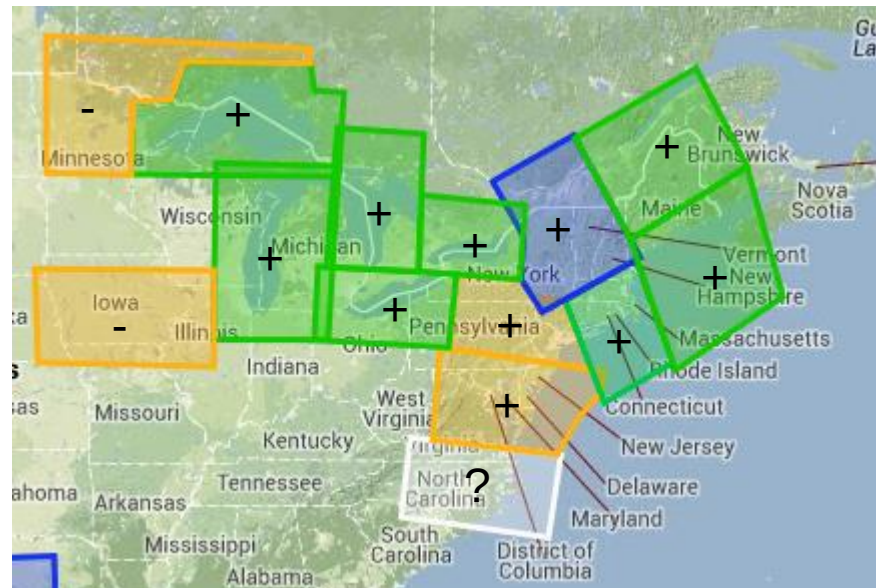
Annually update an experimental gravimetric geoid with GRAV-D data

- Evolution as we move
 - from USGG2012 (last non-GRAV-D gravimetric geoid)
 - through xGG201? (annual experimental geoid)
 - to USGG2022 (the final geoid with GRAV-D)
- Starting 2014: National Ocean Service Requirement

xGG2014

- First experimental geoid model released June, '14
- Online tools for accessing it (GRAV-D website)
- Will include GRAV-D data over the Great Lakes and Northeast, possibly the mid-Atlantic

- + Will be included
- ? May be included
- Not included



How Much Change Do We Expect?

- Geometric Datum
 - Horizontal: 0.8 to 1.5 m in CONUS
 - Ellipsoidal heights: -0.2 to -1.6 m CONUS; AK 0 to 1.3 m
- Vertical Datum
 - Approx. +0.1 m (Florida) to -1.3 m (Washington)
 - More than 2 meters of change in Alaska

How Will NGS Prepare for the New Datums Rollout?

- Work with the FGDC to develop:
 - Standards of Accuracy
 - Specifications, Procedures, and Guidelines
- Develop tools for forward and backward datum conversions
 - The geodetic toolkit will be updated to reflect these
- Develop outreach and training opportunities

NGS Geodetic Tool Kit & Geodetic Software Download

NGS Geodetic Tool Kit

on-line interactive computation of geodetic values

See the text version of an [article](#) about the NGS Geodetic Toolkit that appeared in the *Professional Surveyor* magazine, May 2003 Volume 23, Number 4

([See all the Professional Surveyor Articles about the NGS Geodetic Toolkit](#))

To learn more about a particular online program, click on its link for a description:

DEFLEC99	LVL_DH	Surface Gravity Prediction
DYNAMIC_HT	Magnetic Declination	Tidal and Orthometric Elevations
G99SSS	NADCON	U.S. National Grid
GEOID99	NAVD 88 Modelled Gravity	Universal Transverse Mercator Coordinates
GEOID03	Online Adjustment User Services	VERTCON
GEOID06	Online Adjustment Utilities User Services	XYZ Coordinate Conversion
USGG2003	OPUS	
HTDP	State Plane Coordinates	
IGLD85		
Inverse/Forward/Invers3D/Forwrd3D		

Download NGS PC Software

download free geodetic software developed by NGS

ADJUST AND UTILITIES	DSWIN	GPCCGP	PROMPTER
CALIBRAT	DSFILES	HTDP	SPCS83
CARIB97	DSUPDATE	INTERORB	TOLADD
COMPGb	ENHANCEMENTS	INV/FWD3D	Translev
COMPVECS	G99SSS	LOOP	USNG
CORPSCON	GEOID99	LVL_DH	UTMS
CR8BB	GEOID03	MEXICO97	VDatum
CR8SER	GEOID06	MTEN4	VERTCON
DCAR97	Gethv1st	NA2VBBK	WinDesc
DEFLEC99	USGG2003	NADCON	XYZWIN
DMEX97		PCVOBS	

[Software Download FAQ](#) | [Manuals](#)

- datum/coordinate conversion
- time-dependent positioning
- datasheet utilities
- geodetic utilities
- geoid modeling

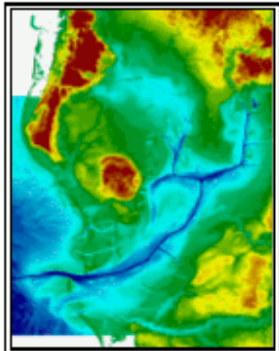
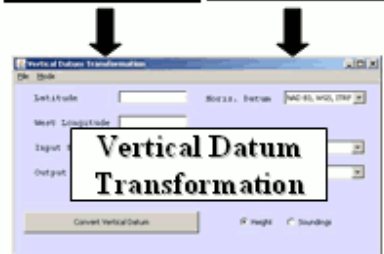
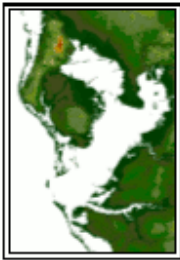
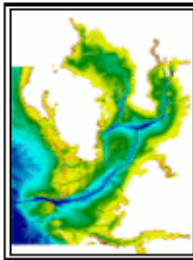
- gravity prediction
- network adjustment
- GPS project analysis
- project submission

VDatum: Vertical Datum Transformation Tool

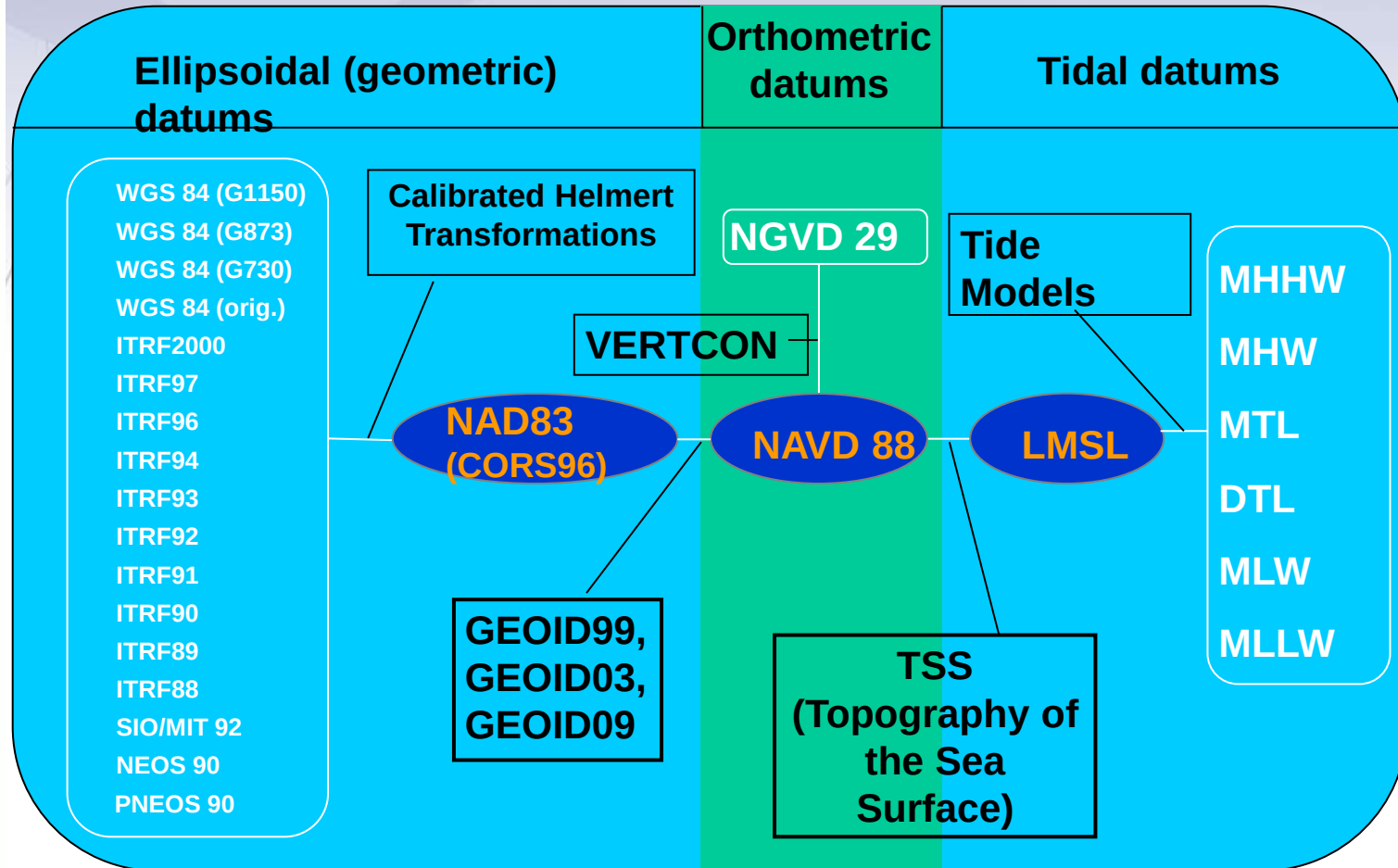
The VDatum Demonstration Project in Tampa Bay, Florida

NOAA Bathymetry

USGS Topography



Integrated Bathy/Topo DEM



VDatum is a software tool capable of transforming coastal bathymetry and land topographic elevations between 36 different vertical datums.

<http://vdatum.noaa.gov/>

How can you prepare?

- Move to newest realizations
 - NAD 83(2011) epoch 2010.00
 - USGG12 (gravimetric geoid) / GEOID12A (hybrid geoid)
- Obtain precise ellipsoid heights on NAVD 88 bench marks (OPUS-DB, contact NGS Geodetic Advisor)
 - Improves hybrid geoid models and provides “hard points” in new vertical datum
 - Follow new NGS Guidelines when released
- Move off of NGVD 29 to NAVD 88
 - Understand the accuracy of VERTCON in your area
- Move away from passive marks to GNSS
 - Especially move off of classical passive control
- Require/provide complete metadata for all mapping contracts
 - How did they get the positions/heights? Document it!!

Metadata is Critical

- Your positional metadata should include:
 - datum
 - epoch
 - source
- These will facilitate transforming from current to new datum
- Maintaining your original survey data will provide more accurate results

Education and Outreach

- Get state legislatures to remove all references to “NAVD 88” and/or “NAD 83” on the books
 - New wording “*National Spatial Reference System*”
- Visit Informational Web Pages at NGS
 - Videos
 - Flyers
- Attend Regional Presentations and Webinars
- **Priorities for NGS’ 10-Year Plan**
- **Some Information Already Available**



geodesy.noaa.gov

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Announcements: New Version of the NOAA Shoreline Data Explorer



Notices

Updated Release: Beta Version
05.30.2013

NGS Announces Release of Geoid
Survey 2011 (GSVS11), 02.01.2012

NGS Releases Updated Ten-Year

NGS Announces Joint Beta Release
01.18.2013

NGS updates "Bluebooking" process

DEFLEC12A and USDOV2012 Models Released, 10.19.2012

GEOID12A Model Released, 09.11.2012

In The News

12/19/2013 - NOAA Submits Report to GGOS Inter-Agency Committee (NGS)

NOAA has been engaged with the Global Geodetic Observing System (GGOS) and submitted a report the week of December 9 to the GGOS Inter-Agency Committee on current geodetic activities and advancements. One of the primary goals of GGOS is to provide global spatial and temporal changes...[more](#)

12/12/2013 - Sentinel Site Program Organizes Anchialine Pool Elevation Work

Researchers in Hawaii are now receiving GPS-derived elevation data for anchialine pools (landlocked bodies of water tidally influenced through subterranean connections) along Hawaii's west coast. These data aid managers and researchers in determining how climate change...[more](#)

12/12/2013 - NGS at 46th Annual Meeting of the American Geophysical Union

The National Geodetic Survey (NGS) contributed sessions, papers, and analyses at the **46th Annual American Geophysical Union (AGU) meeting** in San Francisco from December 9 to 13...[more](#)

Datums ▶

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Geodesy

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Geodetic Resources

Geoid

GPS

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Federal Geodetic Control Subcommittee
of the **fgdc**

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[UFCORS](#)

Upcoming Events

NGS Corbin, VA Training Center

<http://www.ngs.noaa.gov/corbin/calendar.shtml>

Calendar of Upcoming Classes

National Geodetic Survey

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To Register for a Webinar:

Follow the 'Register' link on the webpage describing the class content. Click here for webinar **Frequently Asked Questions**.

To Register for a Classroom-based Session:

Click on the appropriate link in the table below, which will take you to a short registration form.

- For classroom-based sessions, we request at least a **3-week notice** if you cannot make a class for which you registered. While we understand that schedules and circumstances change, there are minimum class sizes, and last-minute cancellations can negatively affect other attendees and NGS staff.
- NGS will make every effort to conduct all classes as shown below; however, changes to the schedule may arise due to budget constraints or other considerations. In the event of any changes, those registered for the class will be notified as soon as possible, with at least a 2-week notice.

Unless otherwise noted, classes are free of charge.

For a list of workshops and conferences sponsored or attended by NGS, visit [this page](#).

Date	Name of Class	Status	Trainer(s)	Audience	Classroom / Webinar
1/16/14 - 1/17/14	OPUS Projects Manager's Training , Raleigh, NC	Class full, email for waiting list.	Scott Lokken, NC Geodetic State Advisor	Open to all federal, state, local and private organizations	classroom
2/6/14 - 2/7/14	OPUS Projects Manager's Training, Helena, MT	Class full	Mark Armstrong, OR Geodetic State Advisor	Open to Montana DOT employee only	classroom
4/15/14 - 4/17/14	Geodetic Digital Leveling Class	Register	Charlie Geoghegan and Malcolm Archer-Shee	Open to all federal, state, local and private organizations	classroom
5/13/14 - 5/14/14	OPUS Projects Manager's Training , Corbin VA (tentative)	Class full, email for waiting list.	Dan Martin, VT Geodetic State Advisor	Open to all federal, state, local and private organizations	classroom



May 21, 2014

NGS Training/Online Learning Email Notifications

If you would like to receive an email informing you of upcoming training/learning opportunities presented by NOAA's National Geodetic Survey, please fill in the information below.

* Required

Your email address *

Organization you are affiliated with

optional

- ☐ Federal government
- ☐ State government
- ☐ Local government
- ☐ Private company
- ☐ Academia
- ☐ Nonprofit organization
- ☐ other

State or Territory

optional

Submit

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Mailing List

Predicated Positional Changes in 2022 near Gaithersburg. Computed for OBSERVATORY RM 1 (JV4124)

HORIZONTAL = 1.15 m (3.6 ft)

ELLIPSOID HEIGHT = - 1.28 m (- 4.2 ft)

Computed with [HTDP](#)

ORTHOMETRIC HEIGHT = - 0.39 m (- 1.3 ft)

Computed with [xGEOID14B](#)

Can be easily computed from OPUS Extended Output

- 1: INVERSE NAD 83 (2011) and IGS08 Lat/Long**
- 2: Subtract NAD 83 (2011) Eht from IGS08 Eht**
- 3: Extended output gives estimated 2022 Orthometric Height**

What can you do to get ready for 2022??

Understand the impact of changing positions and heights for your community, company or agency

Watch for upcoming NGS status reports/webinars

**Consider changes to MD NAD 83 Legislation
Maryland Code, Real Property, Title 14**

Should NGS continue to publish State Plane Coordinates?

If yes:

Retain or change NAD 83 geometric parameters?

Communicate your issues directly to NGS

Joe Evjen – joe.evjen@noaa.gov – Geometric Datum Manager

Vicki Childers– vicki.childers@noaa.gov – Acting Geopotential Datum Manager

GOOD COORDINATION BEGINS WITH GOOD COORDINATES



GEOGRAPHY WITHOUT GEODESY IS A FELONY