OSU Surveying Workshop

Fundamentals of NSRS

Dave Zenk
NGS Advisor
February 5, 2010
Corvallis, OR

Elements of the National Spatial Reference System

National Geodetic Survey
Corbin, VA
June 2, 2008

Dave Doyle
NGS Chief Geodetic Surveyor
dave.doyle@noaa.gov
301-713-3178

Our Positioning History

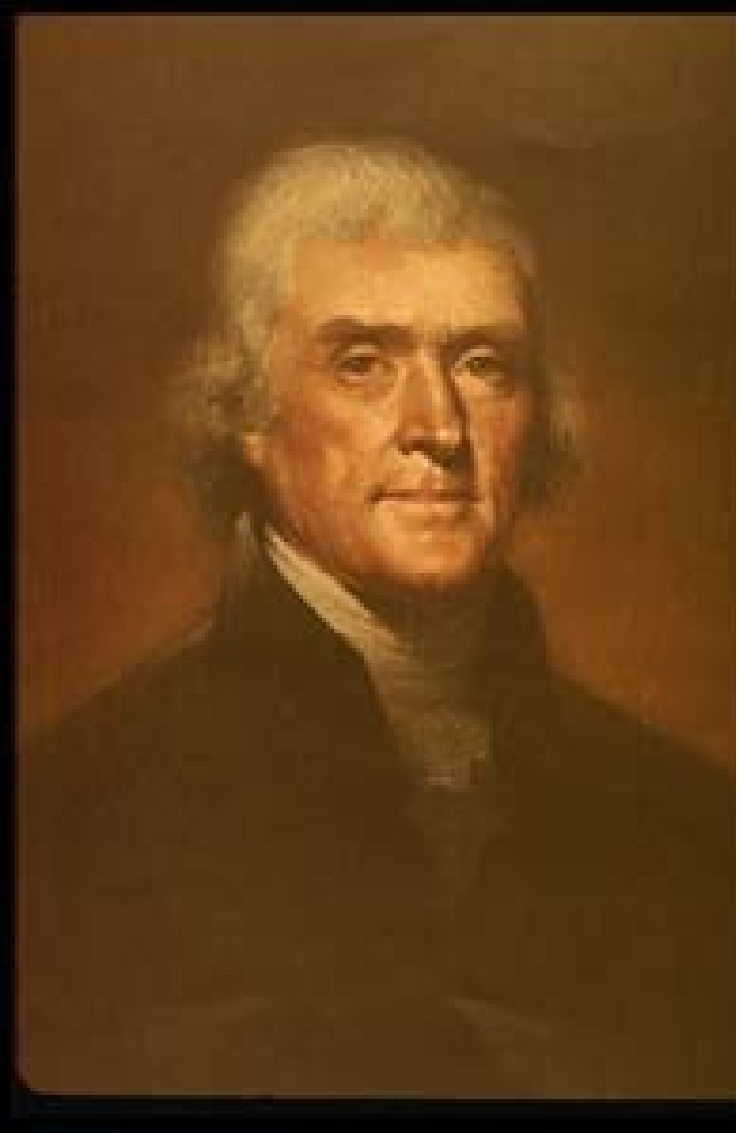
What's In a Name?

1807 - Survey of the Coast

1836 - Coast Survey

1878 - US Coast and Geodetic Survey

1970 - National Ocean Service
National Geodetic Survey



NINTH CONGRESS OF THE UNITED STATES.

At the Second Session.

Begun and held at the city of Washington, in the territory of Columbia, on Monday the first of December, one thousand eight hundred and six.

AN ACT *to provide for surveying the coasts of the United States*

Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled, That the president of the United States shall be, and he is hereby authorized and requested, to cause a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shore of the United States; and also the respective courses and distances between the principal capes, or head lands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coasts within the district aforesaid.

SEC. 2. And be it further enacted, that it shall be lawful for the president of the United States, to cause such examinations and observations to be made, with regard to St. George's bank, and any other bank or shoal, and the soundings and currents beyond the distances aforesaid to the gulph stream, as in his opinion may be especially subservient to the commercial interests of the United States.

SEC. 3. And be it further enacted, that the president of the United States shall be, and he is hereby authorized and requested, for any of the purposes aforesaid, to cause proper and intelligent persons to be employed, and also such of the public vessels in actual service, as he may judge expedient, and to give such instructions for regulating their conduct as to him may appear proper, according to the tenor of this act.

SEC. 4. And be it further enacted, That for carrying this act into effect there shall be, and hereby is appropriated, a sum not exceeding fifty thousand dollars, to be paid out of any monies in the treasury, not otherwise appropriated.

Speaker of the House of Representatives

Vice President of the United States, and President of the Senate.

February 10. 1807

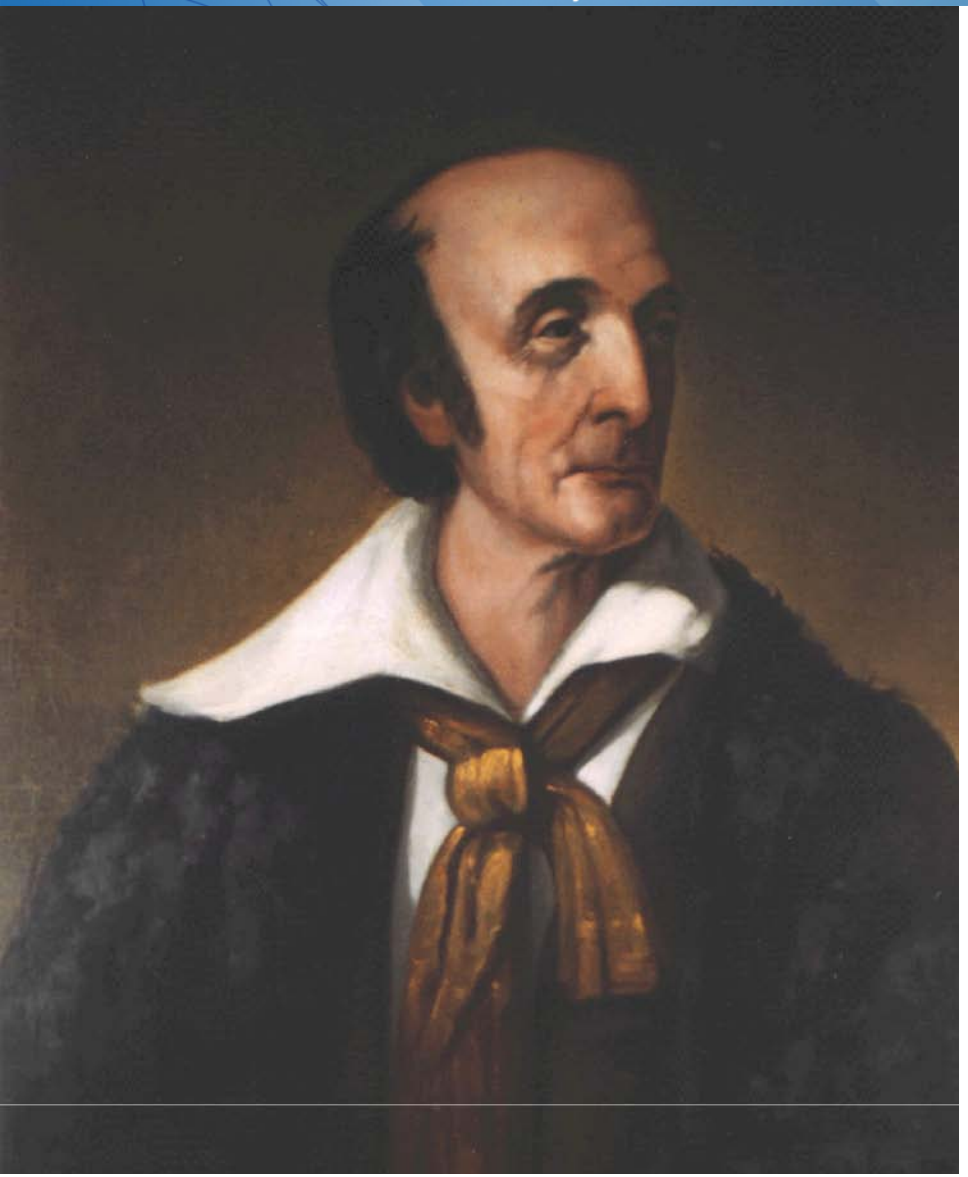
Approved

I certify that this act did originate in the House of Representatives.

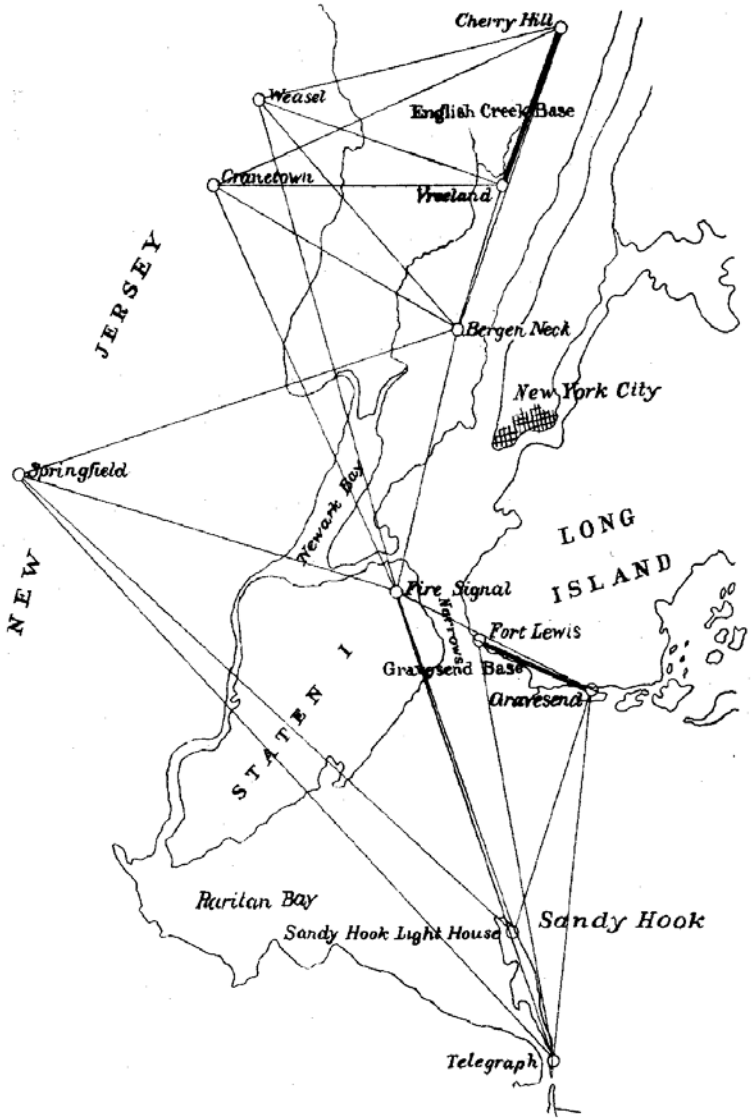
John Beckley Clerk

1807

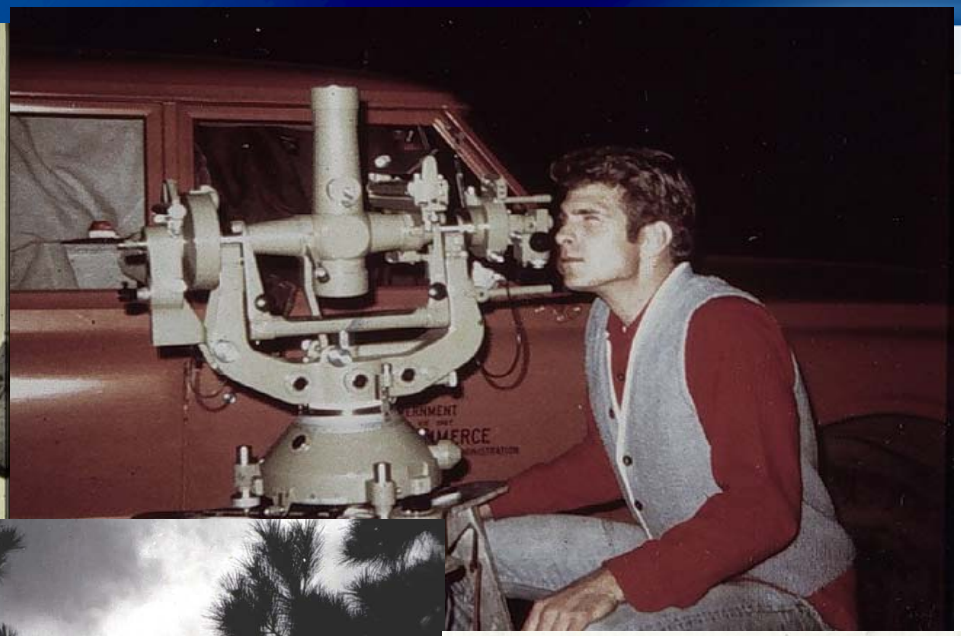
President Thomas Jefferson signs legislation establishing the Survey of the Coast

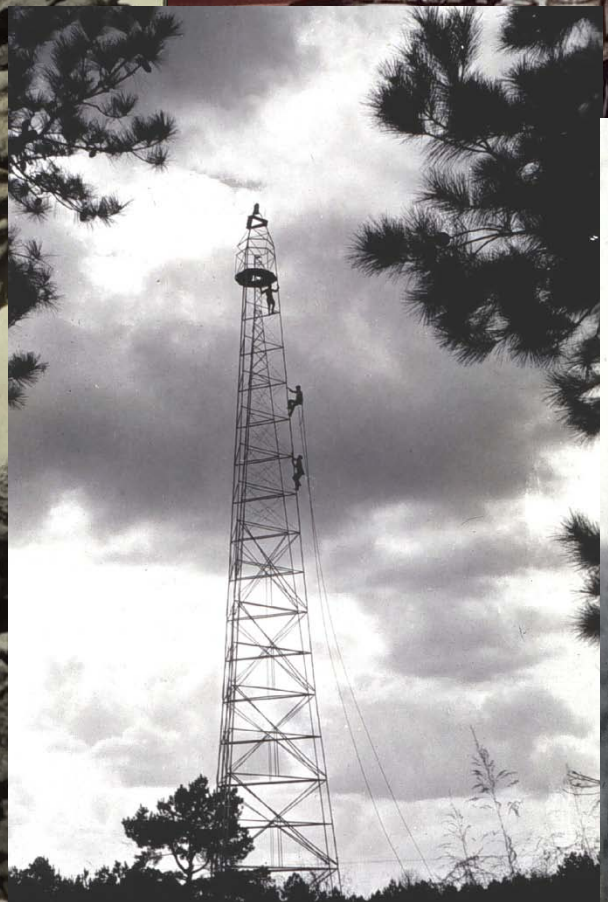


Ferdinand Hassler (1770-1843)

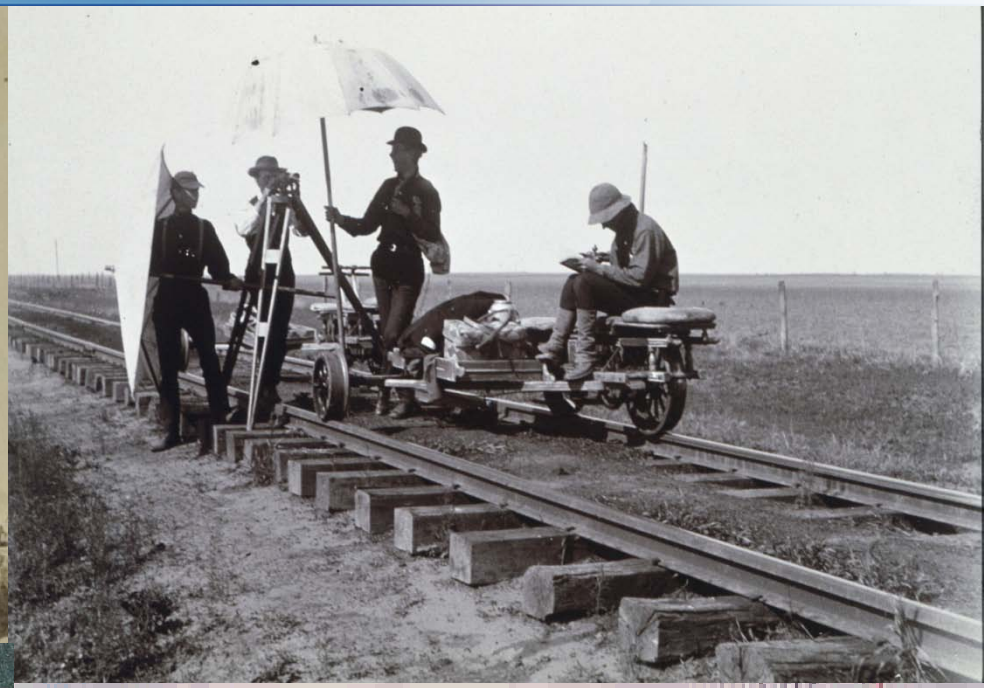


Hassler's First Field Work, 1816–1817






SURVEY



ACRONYMS Я US

National Spatial Reference System (NSRS)

Consistent National Coordinate System

- Latitude
- Longitude
- Height
- Scale
- Gravity
- Orientation

and how these values change with time

FGDC-STD-007.2-1998

Geospatial Positioning Accuracy Standards
Part 2: Standards for Geodetic Networks

Federal Geodetic Control Subcommittee
Federal Geographic Data Committee

Federal Geographic Data Committee
Department of Agriculture • Department of Commerce • Department of Defense • Department of Energy
Department of Housing and Urban Development • Department of the Interior • Department of State
Department of Transportation • Environmental Protection Agency
Federal Emergency Management Agency • Library of Congress
National Aeronautics and Space Administration • National Archives and Records Administration
Tennessee Valley Authority

NOAA Technical Memorandum NOS NGS-58

GUIDELINES FOR ESTABLISHING GPS-DERIVED ELLIPSOID HEIGHTS
(STANDARDS: 2 CM AND 5 CM)
VERSION 4.3

David B. Zilkoski
Joseph D. D'Onofrio
Stephen J. Frakes

Silver Spring, MD

November 1997

NATIONAL SPATIAL REFERENCE SYSTEM

ACCURATE -- cm accuracy on a global scale

MULTIPURPOSE -- Supports Geodesy, Geophysics, Land Surveying, Navigation, Mapping, Charting and GIS activities

ACTIVE -- Accessible through Continuously Operating Reference Stations (CORS) and derived products

INTEGRATED -- Related to International services and standards (e.g. International Earth Rotation and Reference Systems Service, International GNSS Service etc.)

NSRS Coordinate Systems

Latitude & Longitude

State Plane Coordinates

UTM Coordinates

Earth-Centered

Earth-Fixed

NAD 83

NAD 27

NAVD 88

NGVD 29

ITRF00

GEODETIC DATUMS

A set of constants specifying the coordinate system used for geodetic control, i.e., for calculating coordinates of points on the Earth.

Specific geodetic datums are usually given distinctive names. (e.g., North American Datum of 1983, European Datum 1950, National Geodetic Vertical Datum of 1929)

Characterized by:
A set of physical monuments, related by survey measurements and resulting coordinates (horizontal and/or vertical) for those monuments

GEODETIC DATUMS

HORIZONTAL

2 D (Latitude and Longitude) (e.g. NAD 27, NAD 83 (1986))

VERTICAL

1 D (Orthometric Height)
Tidal Datums – MLLW, MSL, MHW etc.

Geodetic Datums -- NGVD 29, NAVD 88

ELLIPSOIDAL

3 D (Latitude, Longitude and Ellipsoid Height) Fixed and Stable Coordinates seldom change (e.g. NAD 83 (2007))

and

4 D (Latitude, Longitude, Ellipsoid Height, Velocities) Coordinates change with time (e.g. ITRF00, ITRF05)

GEODETIC CONTROL

THE REALIZATION OF A DATUM =

A NETWORK OF MONUMENTED POINTS

PRECISELY MEASURED IN ACCORDANCE WITH STANDARD PROCEDURES

THAT MEET ACCURACY SPECIFICATIONS

ADJUSTED TO TIE TOGETHER

AND DOCUMENTED FOR MULTIPLE USE

METADATA
Data About Data

DATUMS

NAD 27, NAD 83(1986), NAD83 (1993), NAD 83 (2007)
NGVD29, NAVD88

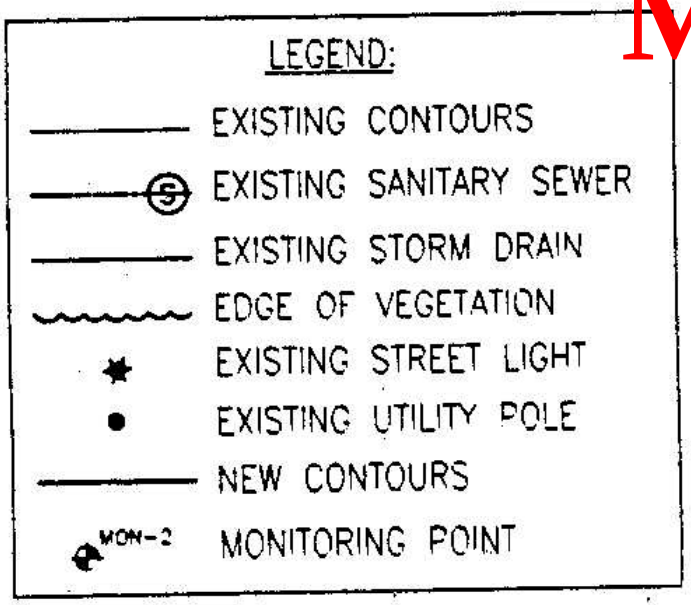
UNITS

Meters, U.S. Survey Feet, International Feet, Varas, Toise, Chains, Rods, Poles, Links, Perches

ACCURACY

A, B, 1st, 2nd, 3rd, 3cm, Scaled

METADATA??



Horizontal Datum??

Plane Coordinate Zone ??

Units of Measure ??

How Accurate ??

MONITORING POINTS

POINT No.	NORTHING	EASTING	ELEV. (MLLW)
MON-1	708,407.42	1,178,660.64	16.91
MON-2	708,270.52	1,178,806.49	18.89
MON-3	708,133.66	1,178,952.30	19.14
MON-4	707,996.80	1,179,098.10	17.39
MON-5	707,859.83	1,179,243.87	18.00

HORIZONTAL/ELLIPSOIDAL DATUMS

8 Constants

3 – specify the location of the origin of the coordinate system.

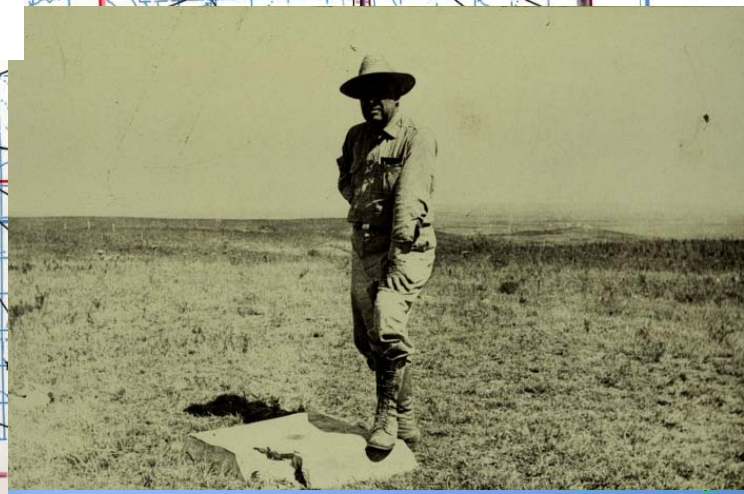
3– specify the orientation of the coordinate system.

2 – specify the dimensions of the reference ellipsoid

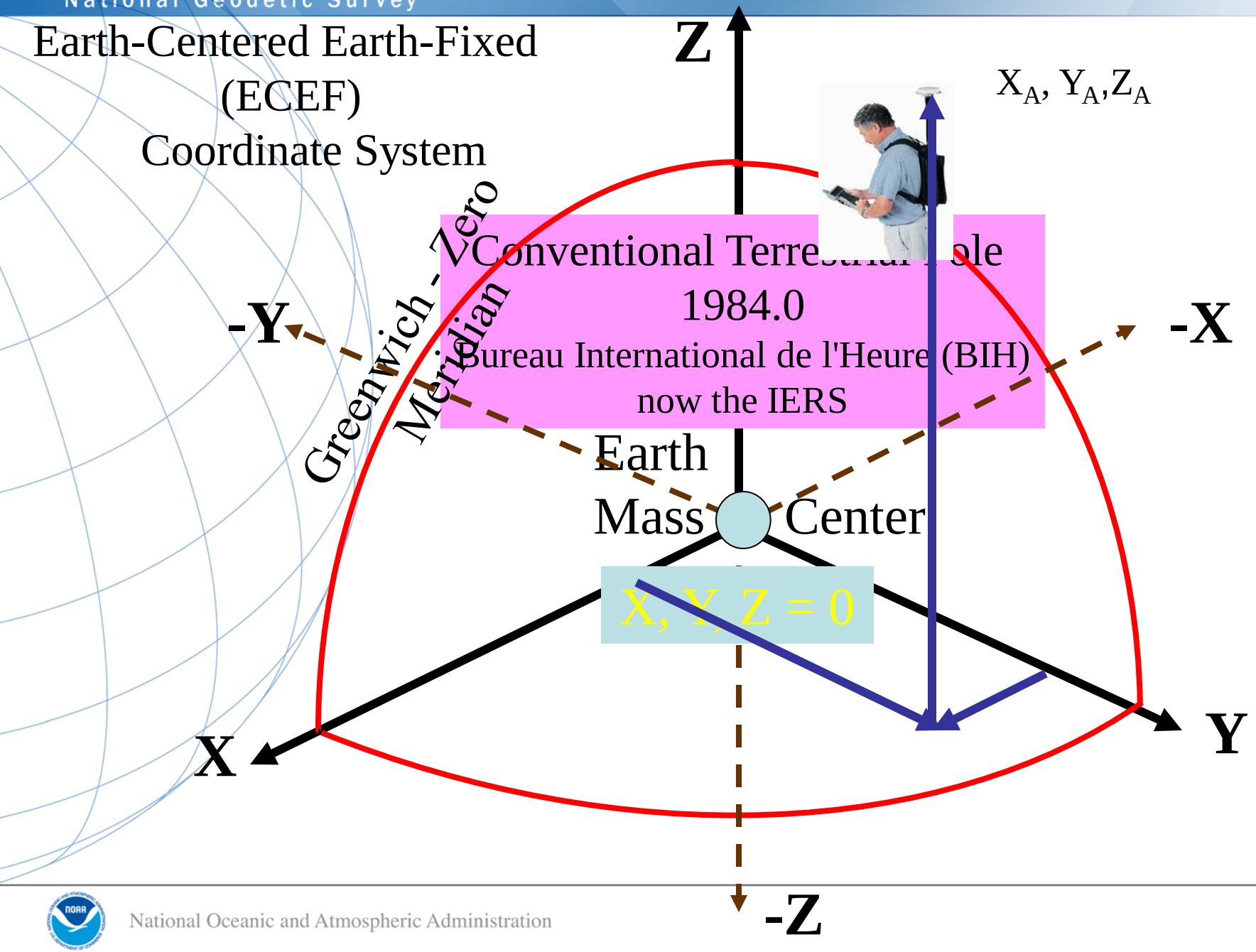
NAD 27

NAD 27
Φ= 39º 13’ 26.686”
λ = 98º 32’ 30.506”
h = 0.000 m

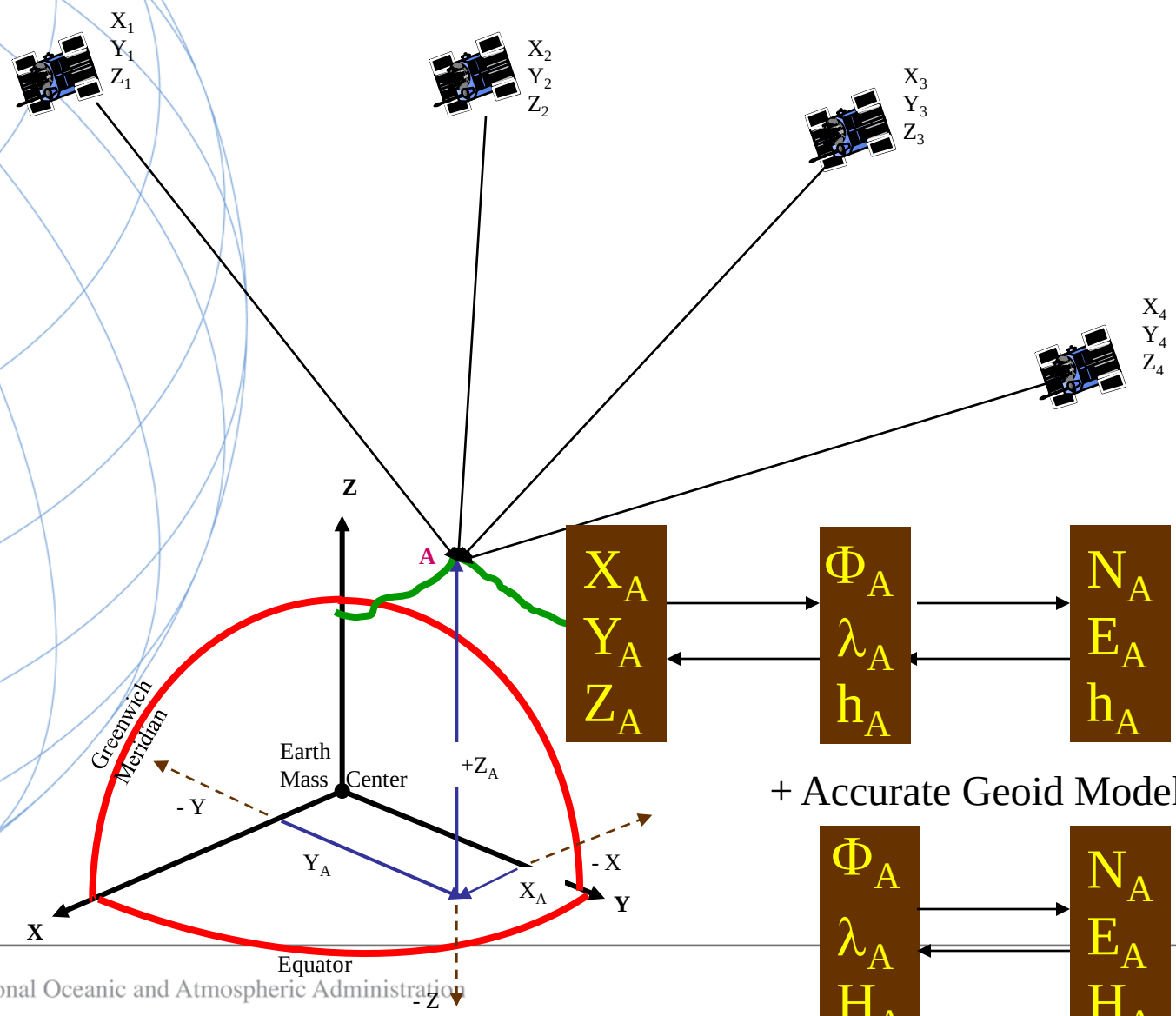
Azimuth
α = 255º 28’ 09.63”
Deflection N-S = 0.00”
Deflection E-W = 0.00”



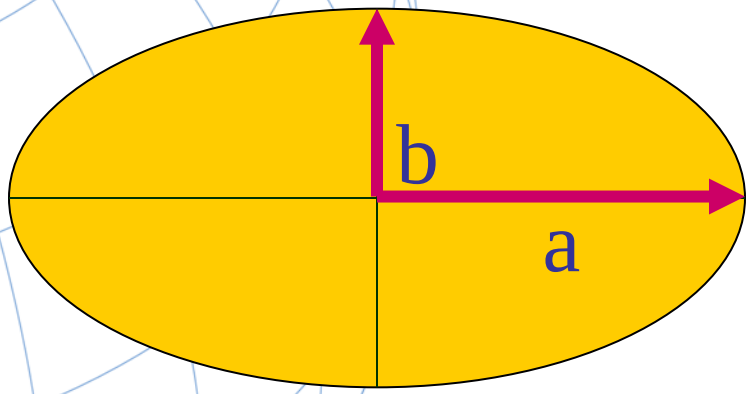
Earth-Centered Earth-Fixed (ECEF) Coordinate System



3-D Coordinates derived from GNSS



THE ELLIPSOID
MATHEMATICAL MODEL OF THE EARTH



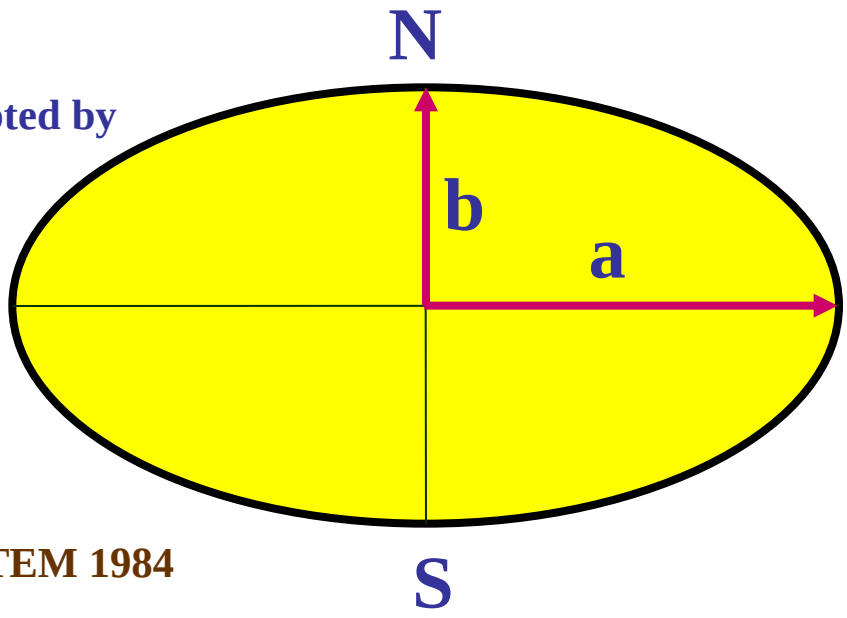
a = Semi major axis
b = Semi minor axis
f = $\frac{a-b}{a}$ = Flattening

Ellipsoid	A	1/f
AIRY 1830	6377563.396	299.3249646
BESSEL 1841	6377397.155	299.1528128
CLARKE 1858	6378293.645	294.26068
CLARKE 1866	6378206.4	294.9786982
CLARKE 1880	6378249.145	294.9786982
EVEREST 1830	6377276.345	300.8017
GRS 80	6378137	298.2572221
HOUGH 1956	6378270	297.0
INTERNATIONAL 1924	6378388	297.0
KRASSOVSKY 1938	6378245	298.3
PZ90	6378136	298.2578390
WGS 60	6378165	298.3
WGS 66	6378145	298.25
WGS 72	6378135	298.26
WGS 84	6378137	298.2572236

UNITED STATES ELLIPSOID DEFINITIONS

GEODETIC REFERENCE SYSTEM 1980
(GRS 80)
(1986 – Present)
a = 6,378,137 m
1/f = 298.257222101
International standard adopted by IAG/IUGG/NGS

CLARKE 1866
(1879 – 1986)
a = 6,378,206.4 m
1/f = 294.97869821
Best fit North America



a = Semi major axis
b = Semi minor axis
f = $\frac{a-b}{a}$ = Flattening

WORLD GEODETIC SYSTEM 1984
(WGS 84)
(1987 – Present)
a = 6,378,137 m
1/f = 298.257223563
Defined for GPS by U.S. DoD

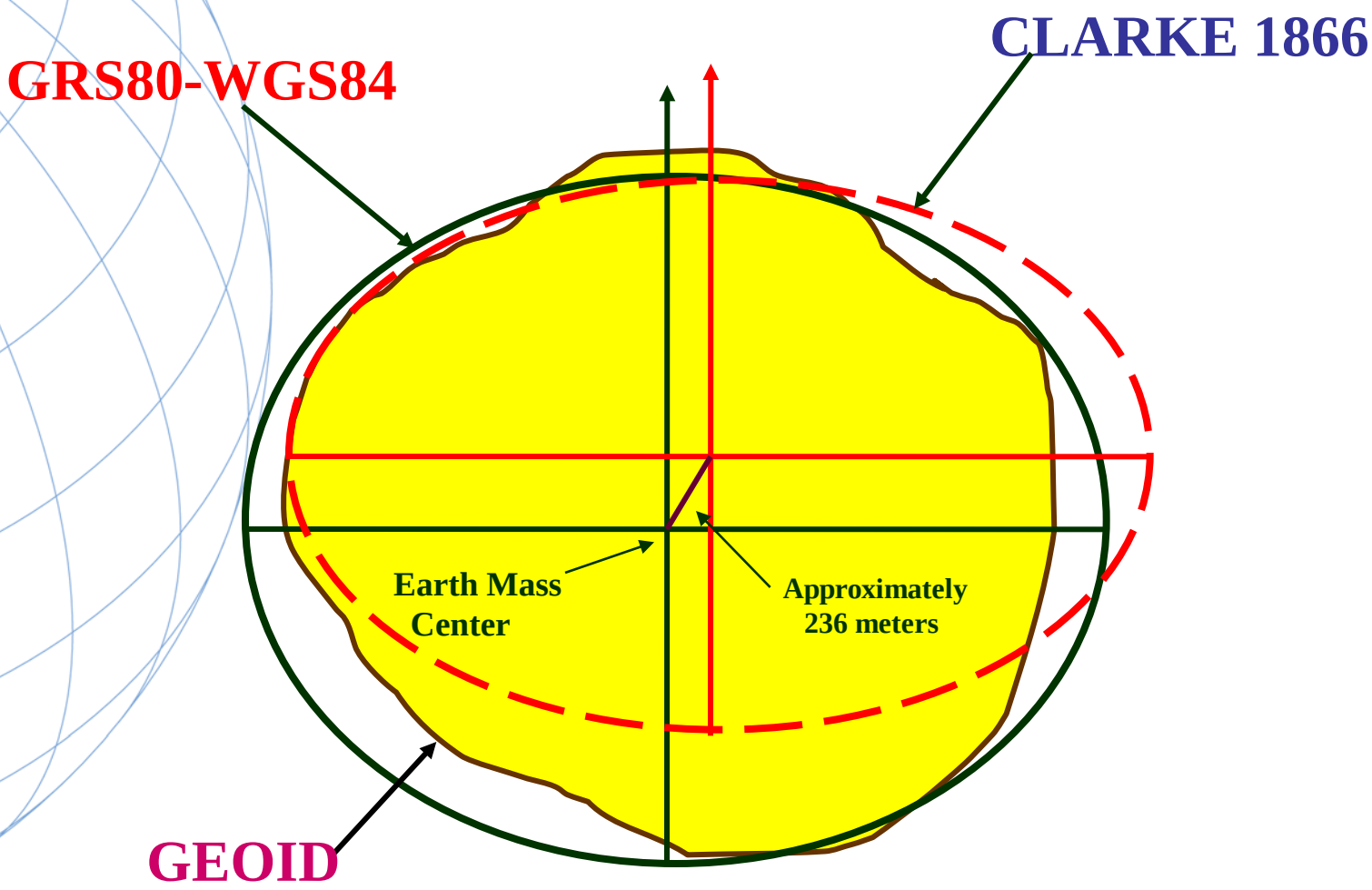
BESSEL 1841
(1851 – 1879)
a = 6,377,397.155 m
1/f = 299.1528128
Best fit East Coast of U.S.

National Spatial Reference System (NSRS)

U.S. HORIZONTAL DATUMS

BESSEL COORDINATES (1851 – 1878)
NEW ENGLAND DATUM (1879 – 1900)
U.S. STANDARD DATUM (1900 – 1913)
ALASKA DATUMS (17 Different 1890 - 1954)
PUERTO RICO DATUM (1901 – 1986)
NORTH AMERICAN DATUM (1913 – 1927)
NORTH AMERICAN DATUM 1927 (1927 – 1986)
OLD HAWAIIAN DATUM (1928 – 1986)
AMERICAN SAMOA DATUM (1962 – 1993)
GUAM DATUM (1963 – 1993)
NORTH AMERICAN DATUM 1983 (1983 – PRESENT)

THE GEOID AND TWO ELLIPSOIDS



Vertical Datums

VERTICAL DATUMS

A set of fundamental elevations to which other elevations are referred.

Datum Types

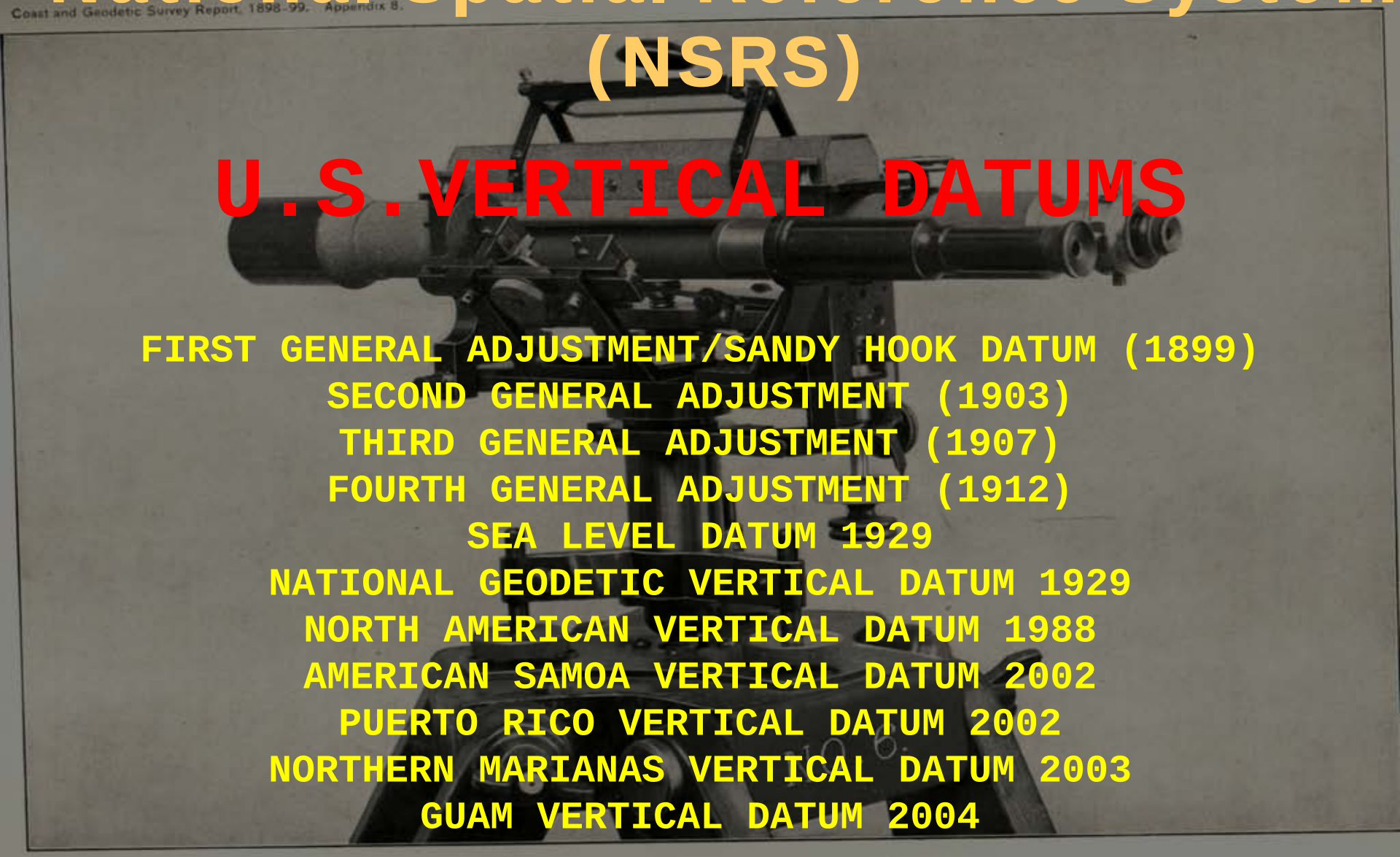
Tidal – Defined by observation of tidal variations over a specified epoch of time

Geodetic – Typically based on Mean Sea Level at one or more points for a specified epoch of time

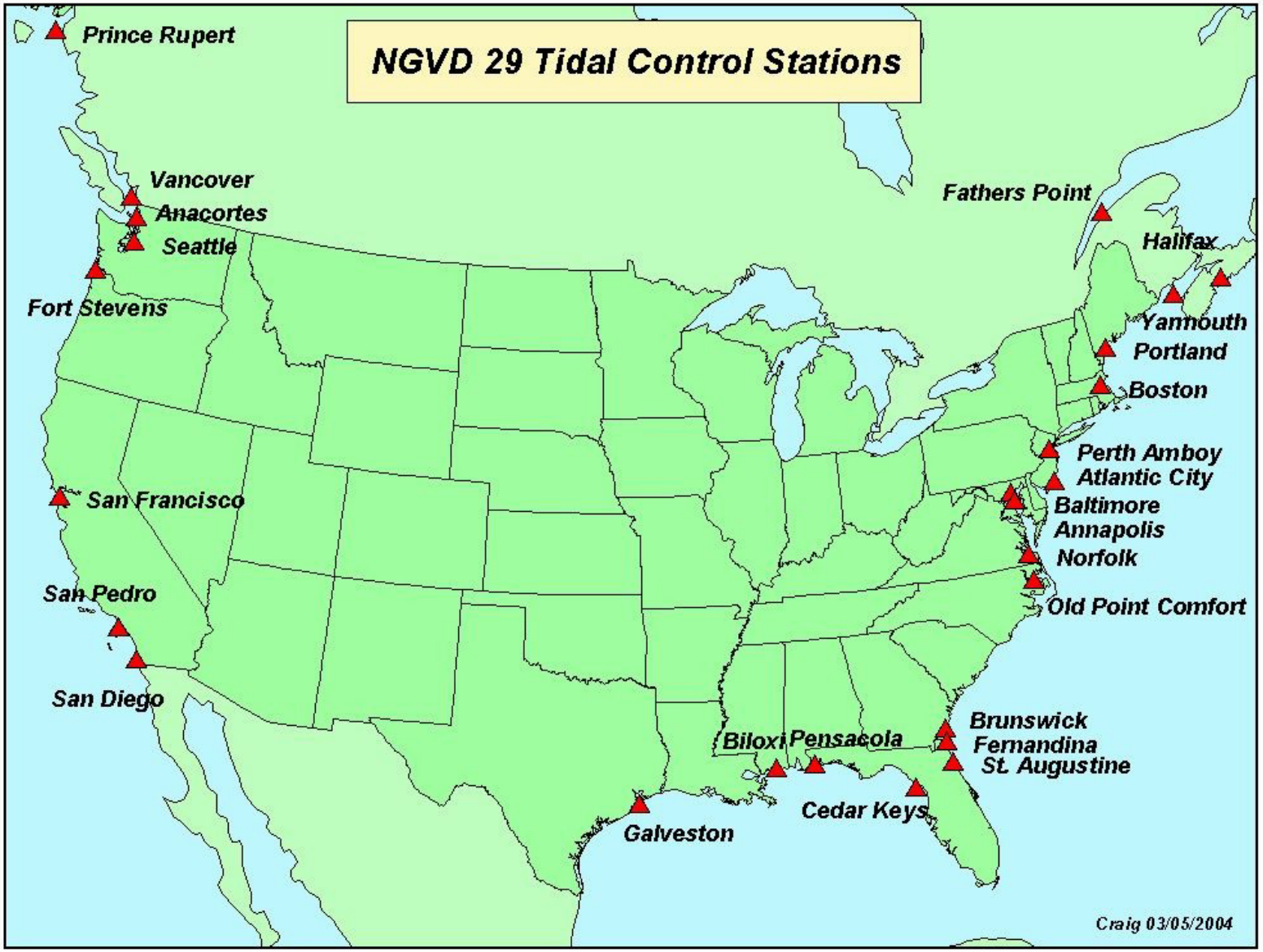
National Spatial Reference System (NSRS)

U.S. VERTICAL DATUMS

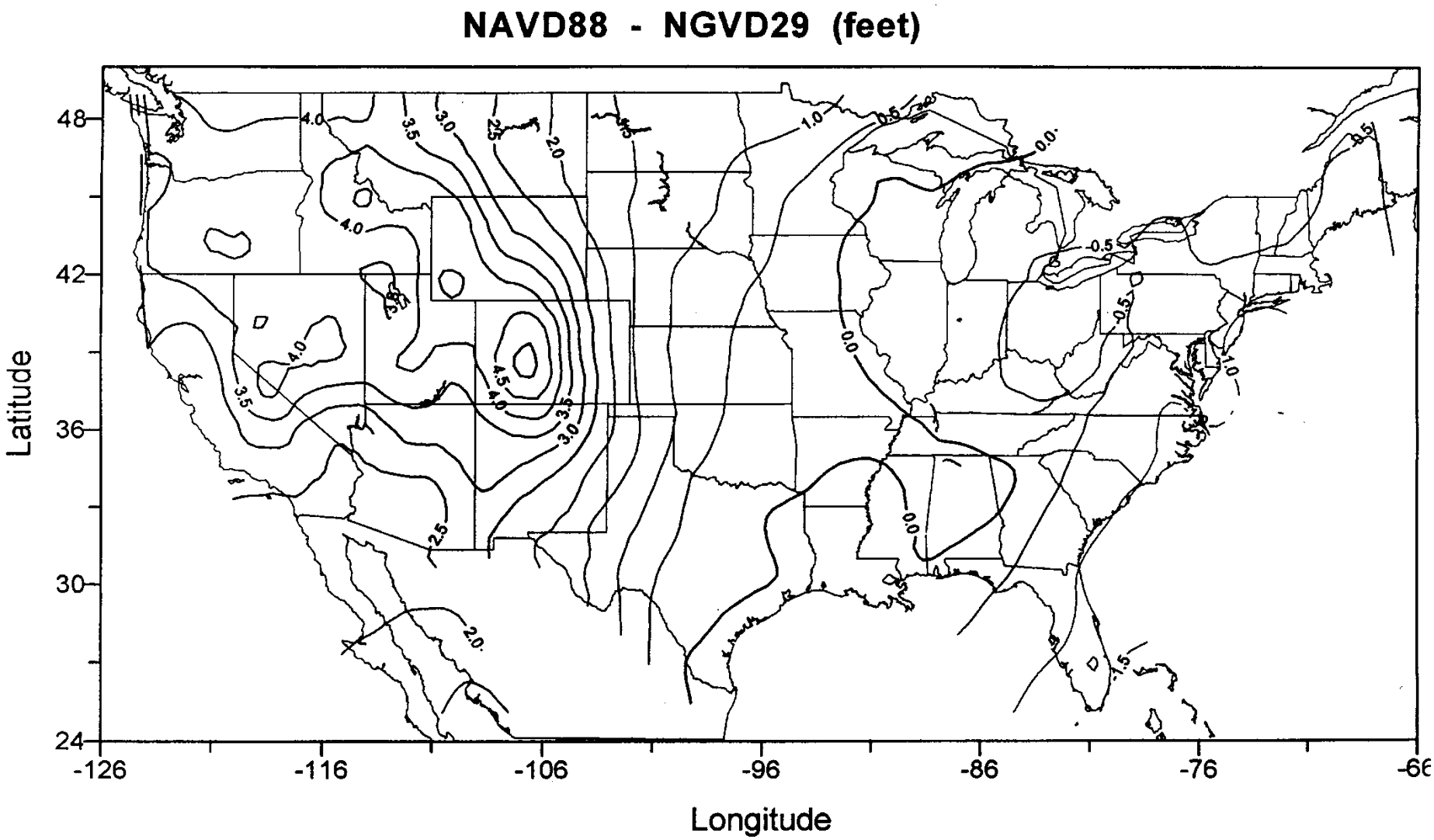
FIRST GENERAL ADJUSTMENT/SANDY HOOK DATUM (1899)
SECOND GENERAL ADJUSTMENT (1903)
THIRD GENERAL ADJUSTMENT (1907)
FOURTH GENERAL ADJUSTMENT (1912)
SEA LEVEL DATUM 1929
NATIONAL GEODETIC VERTICAL DATUM 1929
NORTH AMERICAN VERTICAL DATUM 1988
AMERICAN SAMOA VERTICAL DATUM 2002
PUERTO RICO VERTICAL DATUM 2002
NORTHERN MARIANAS VERTICAL DATUM 2003
GUAM VERTICAL DATUM 2004



NGVD 29 TIDE CONTROL



NGVD 29 and NAVD 88



NAVD 88 and LMSL

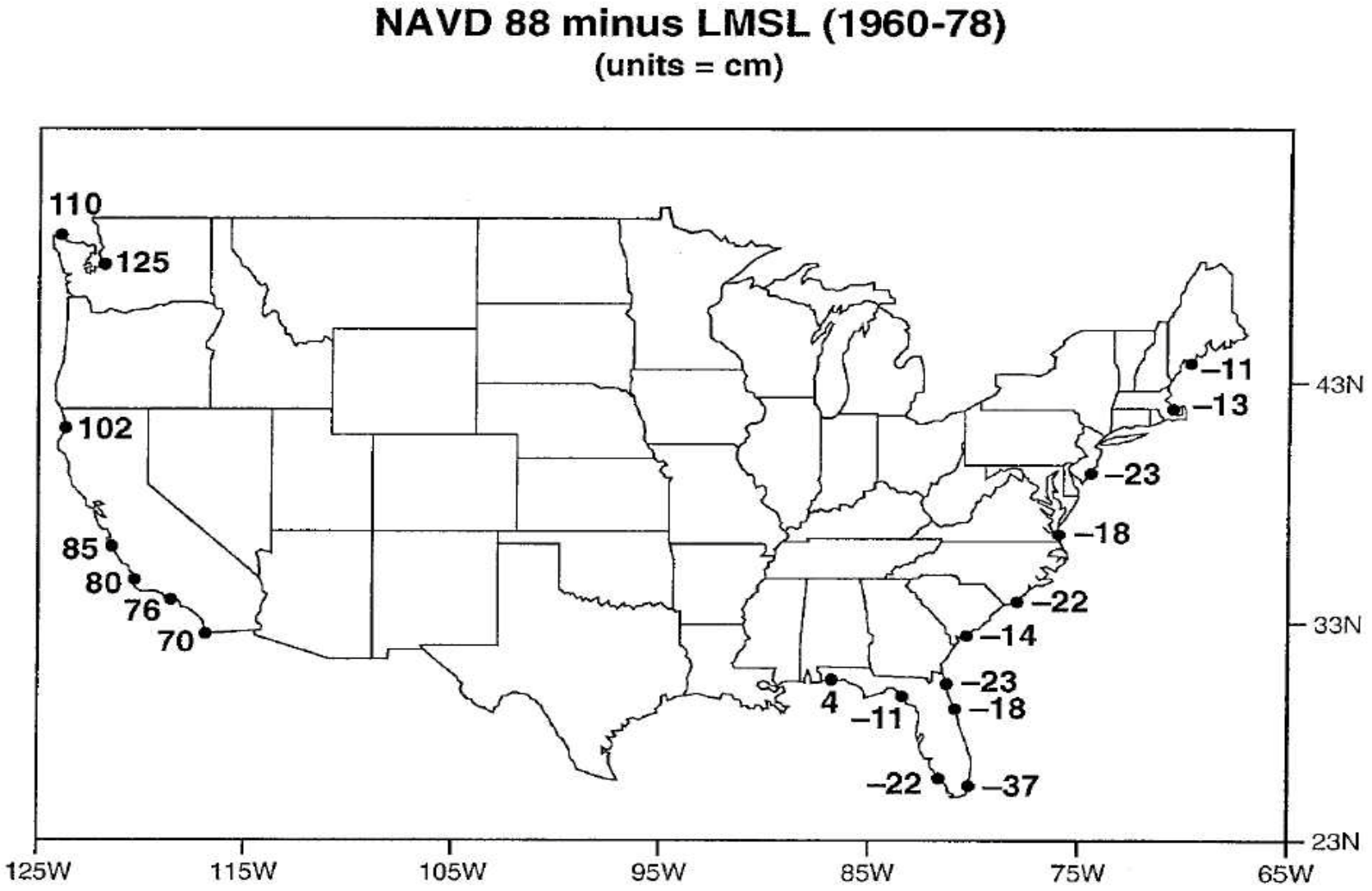


Figure 2.8. Height differences between NAVD 88 and heights of tidal bench marks above LMSL (1960-78 NDTE) (units = cm).

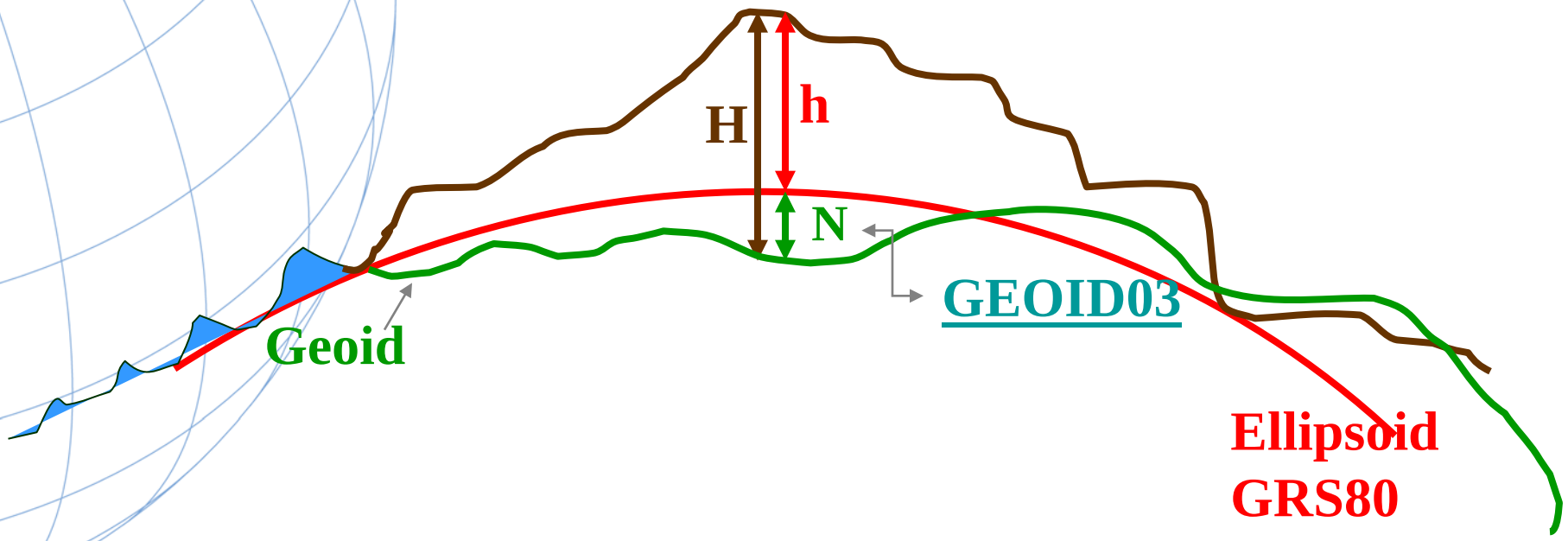
ELLIPSOID - GEOID RELATIONSHIP

H = Orthometric Height (NAVD 88)

h = Ellipsoidal Height (NAD 83)

N = Geoid Height (GEOID 03)

$$H = h - N$$



International Earth Rotation and Reference System Service

www.iers.org

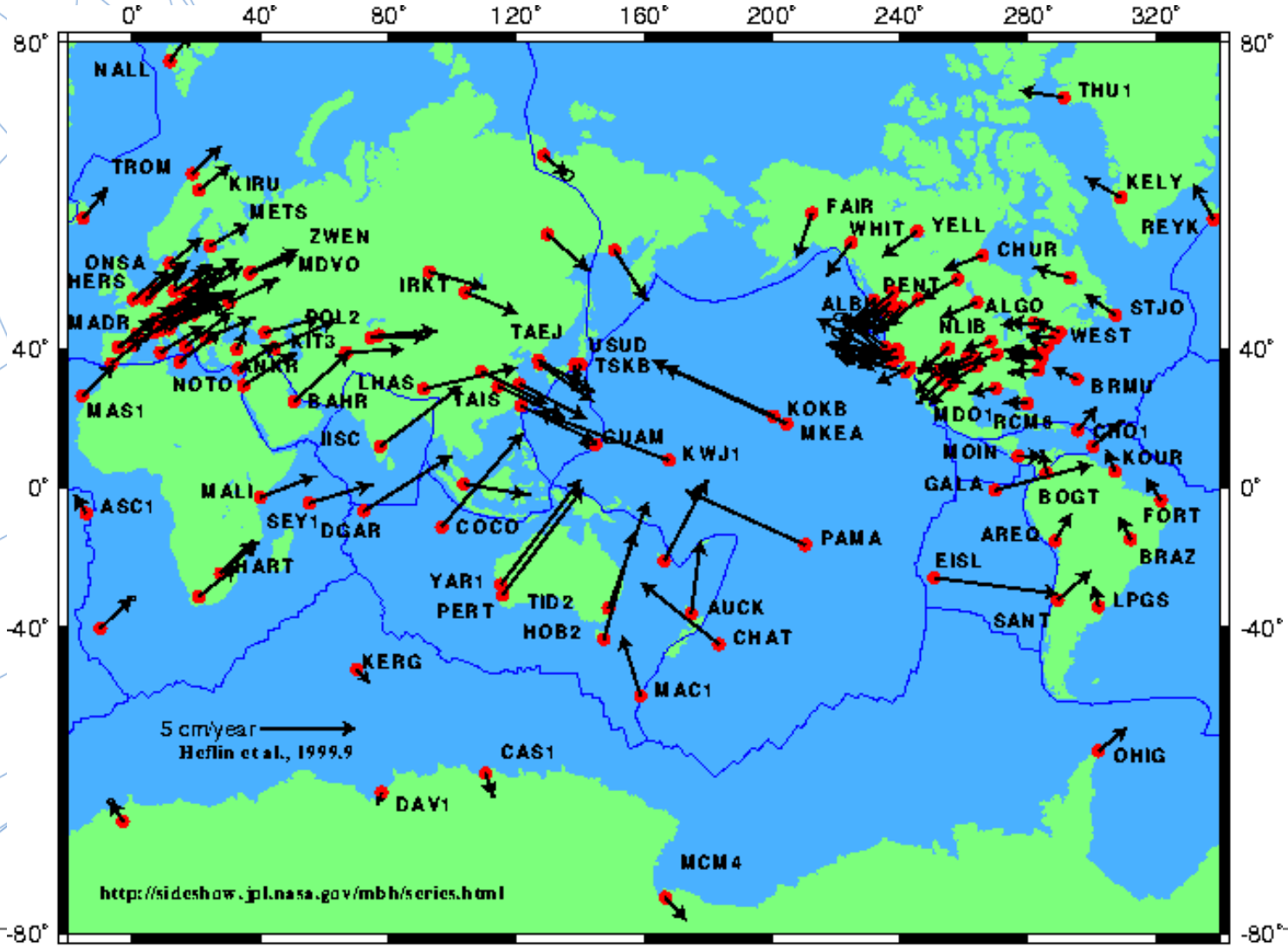
The International Terrestrial Reference System **(ITRS)** constitutes a set of prescriptions and conventions together with the modeling required to define origin, scale, orientation and time evolution

ITRS is realized by the International Terrestrial Reference Frame (**ITRF**) based upon estimated coordinates and velocities of a set of stations observed by:

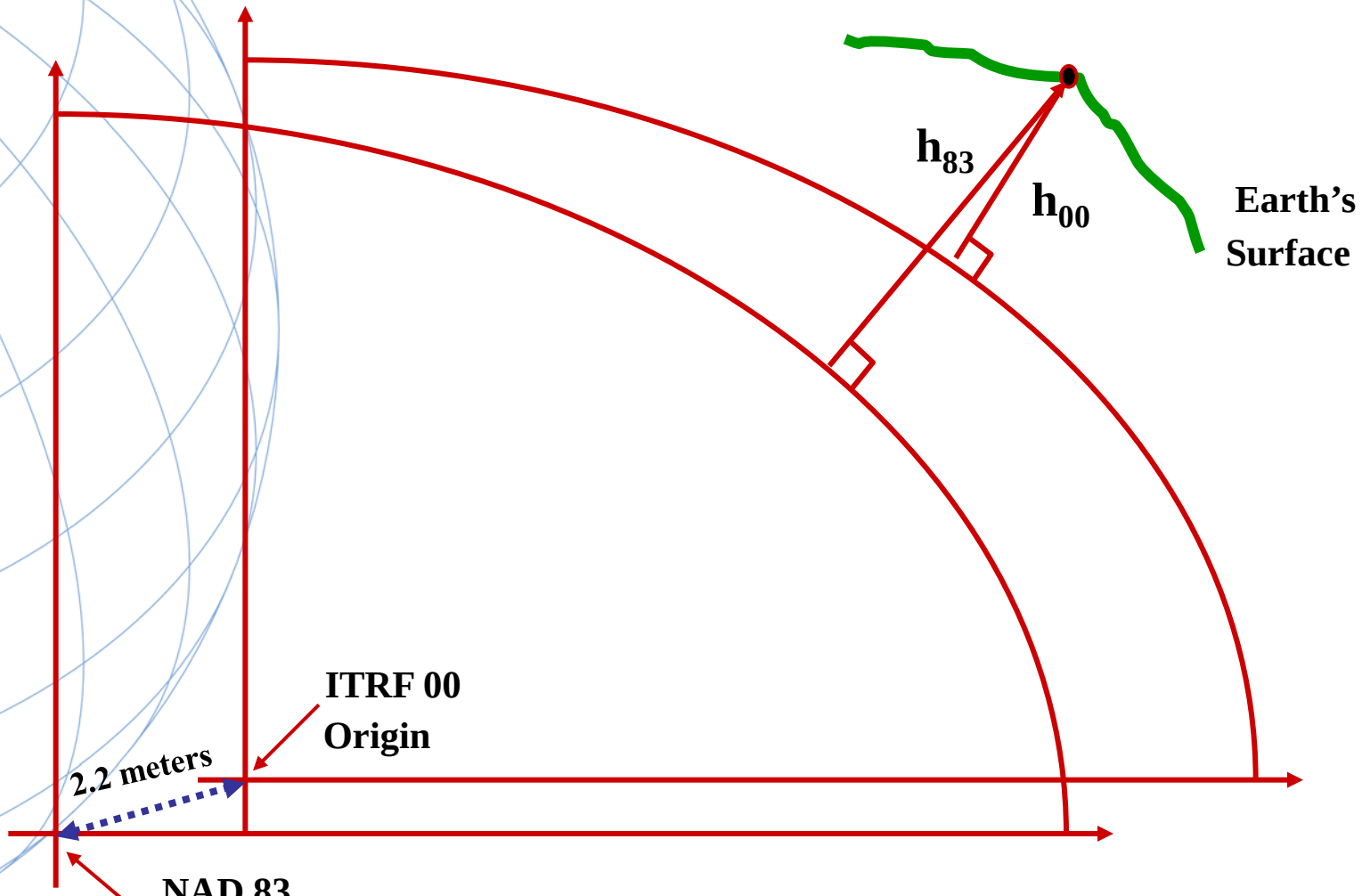
- Very Long Baseline Interferometry (**VLBI**),
- Satellite Laser Ranging (**SLR**),
- Global Positioning System and GLONASS (**GNSS**), and
- Doppler Orbitography and Radio- positioning Integrated by Satellite (**DORIS**).

ITRF89, ITRF90, ITRF91, ITRF92, ITRF93, ITRF94, ITRF96, ITRF97, ITRF2000, ITRF2005

Tectonic Motions



Simplified Concept of ITRF 00 vs. NAD 83

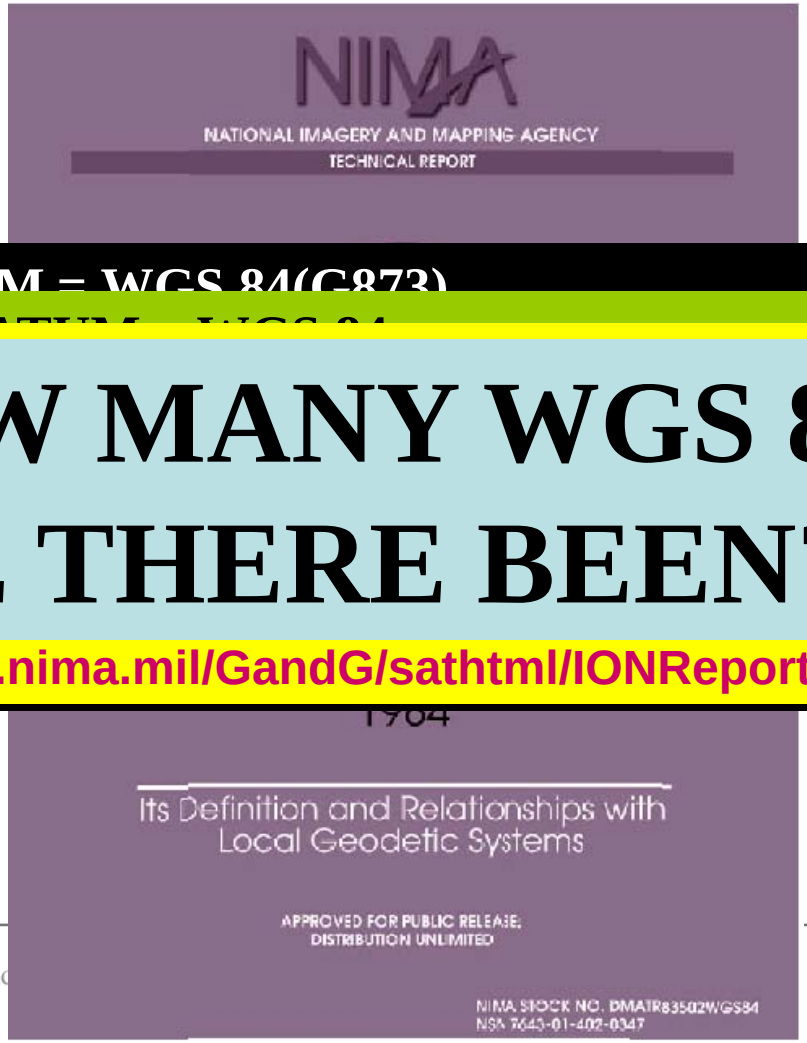


Identically shaped ellipsoids (GRS-80)
a = 6,378,137.000 meters (semi-major axis)
1/f = 298.25722210088 (flattening)

International Terrestrial Reference Frame
4 Global Independent Positioning Technologies

WORLD GEODETIC SYSTEM 1984

http://earth-info.nga.mil/GandG/publications/tr8350.2/wgs84.pdf



D DATUM = WGS 84(G873)

HOW MANY WGS 84s HAVE THERE BEEN????

http://earth-info.nima.mil/GandG/sathtml/IONReport8-20-02.pdf

Appendix B.6

Transformation Parameters

Local Geodetic Datums to WGS 84

Continent: NORTH AMERICA

Local Geodetic Datums		Reference Ellipsoids and Parameter Differences			No. of Satellite Stations Used	Transformation Parameters								
Name	Code	Name	Δa(m)	Δf x 10^4		Cycle Number	Pub. Date	ΔX(m)		ΔY(m)		ΔZ(m)	
NORTH AMERICAN 1983 (cont'd)	NAR	GRS 80	0	-0.00000016									
CONUS	NAR-C				216	0	1987	0	±2	0	±2	0	±2
Hawaii	NAR-H				6	0	1993	1	±2	1	±2	-1	±2
Mexico and Central America	NAR-D				25	0	1987	0	±2	0	±2	0	±2

Federal Register Notice: Vol. 60, No. 157, August 15, 1995, pg. 42146
"Use of NAD 83/WGS 84 Datum Tag on Mapping Products"

MY SOFTWARE SAYS I'M WORKING IN WGS 84

Unless you're doing autonomous point positioning you're probably not in WGS 84

Project tied to WGS-84 control points obtained from the Defense Department -- Good Luck!

You're really working in the same reference frame as your control points -- NAD 83?

NORTH AMERICAN DATUM 1983

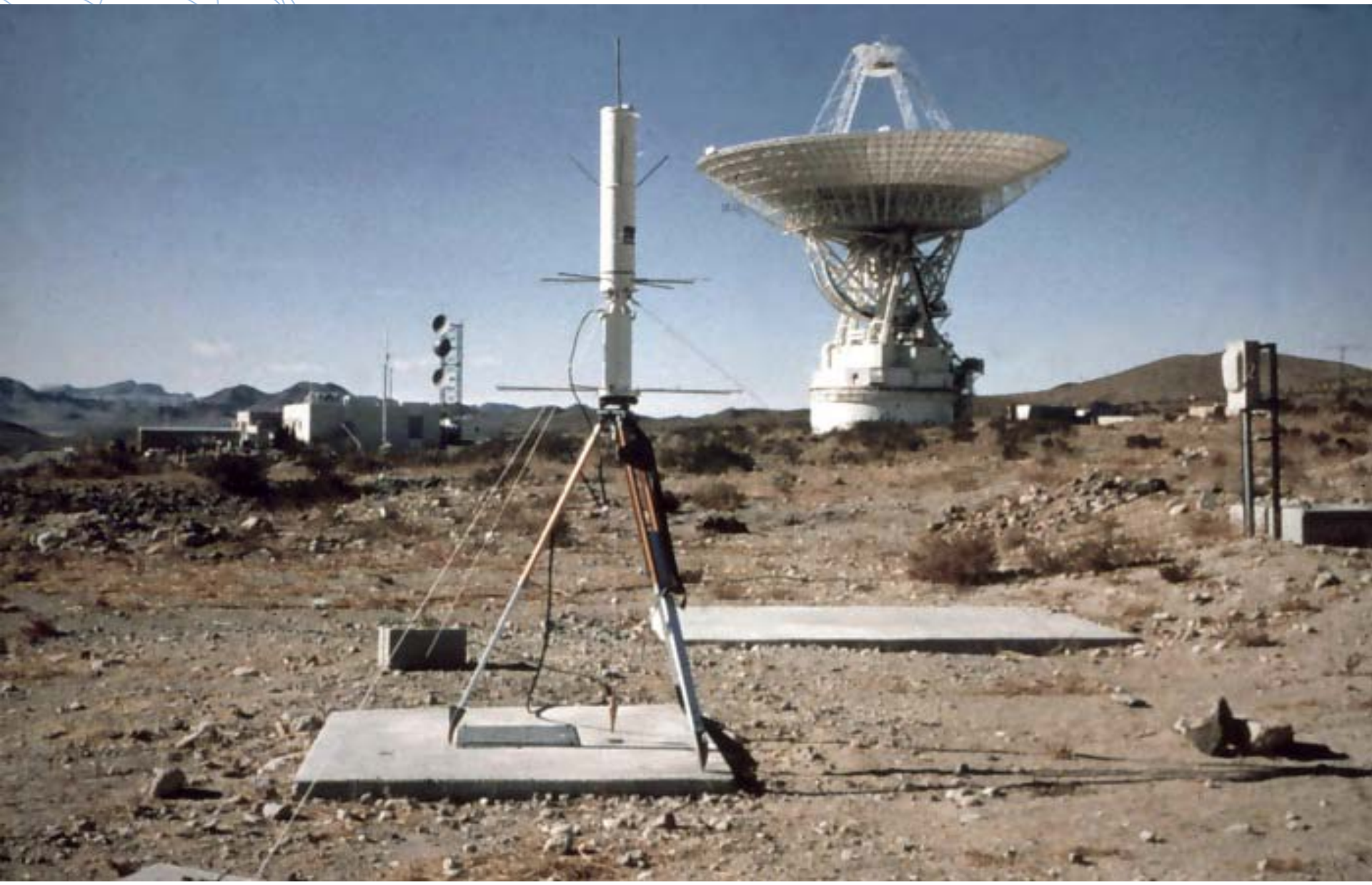
STARTED IN JULY, 1974
PUBLISHED IN AUGUST, 1986

4,997 INDIVIDUAL SURVEYS
266,436 STATIONS
1.8 MILLION OBSERVATIONS

DEFINED AS GEOCENTRIC
W/GLOBALLY BEST FITTING ELLIPSOID – GRS80

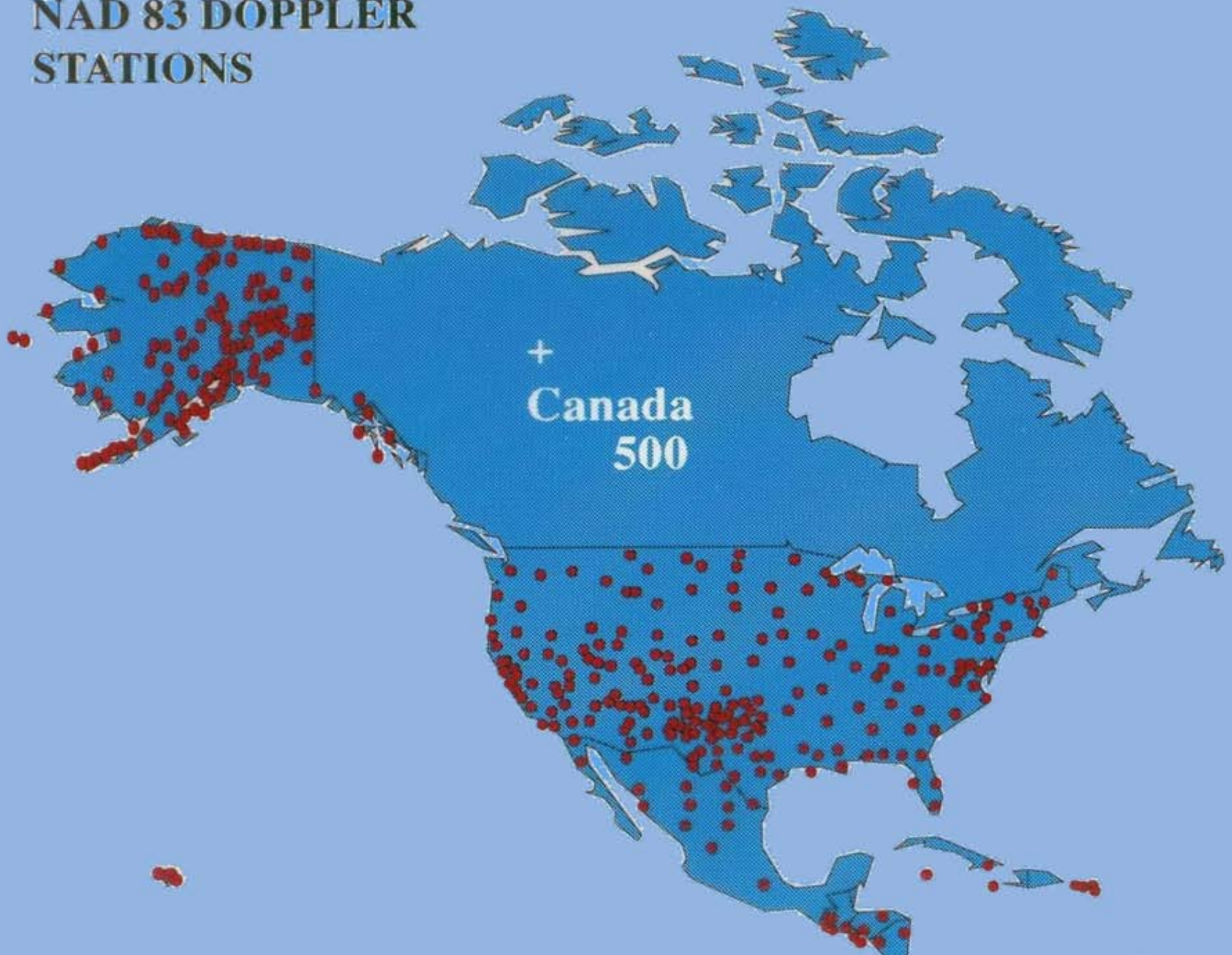
BASED PRIMARILY ON MORE THAN
150 YEARS OF TRIANGULTAION

DOPPLER and VLBI



NAD 83 VLBI STATIONS

NAD 83 DOPPLER STATIONS



EARLY NAD 83 NETWORK PROBLEMS

NOT “GPSABLE”

POOR STATION ACCESSIBILITY

IRREGULARLY SPACED

POSITIONAL ACCURACY

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)

FEDERAL AND COOPERATIVE BASE NETWORKS (FBN/CBN) 1997 - 2004

MORE STATE PARTNERSHIPS

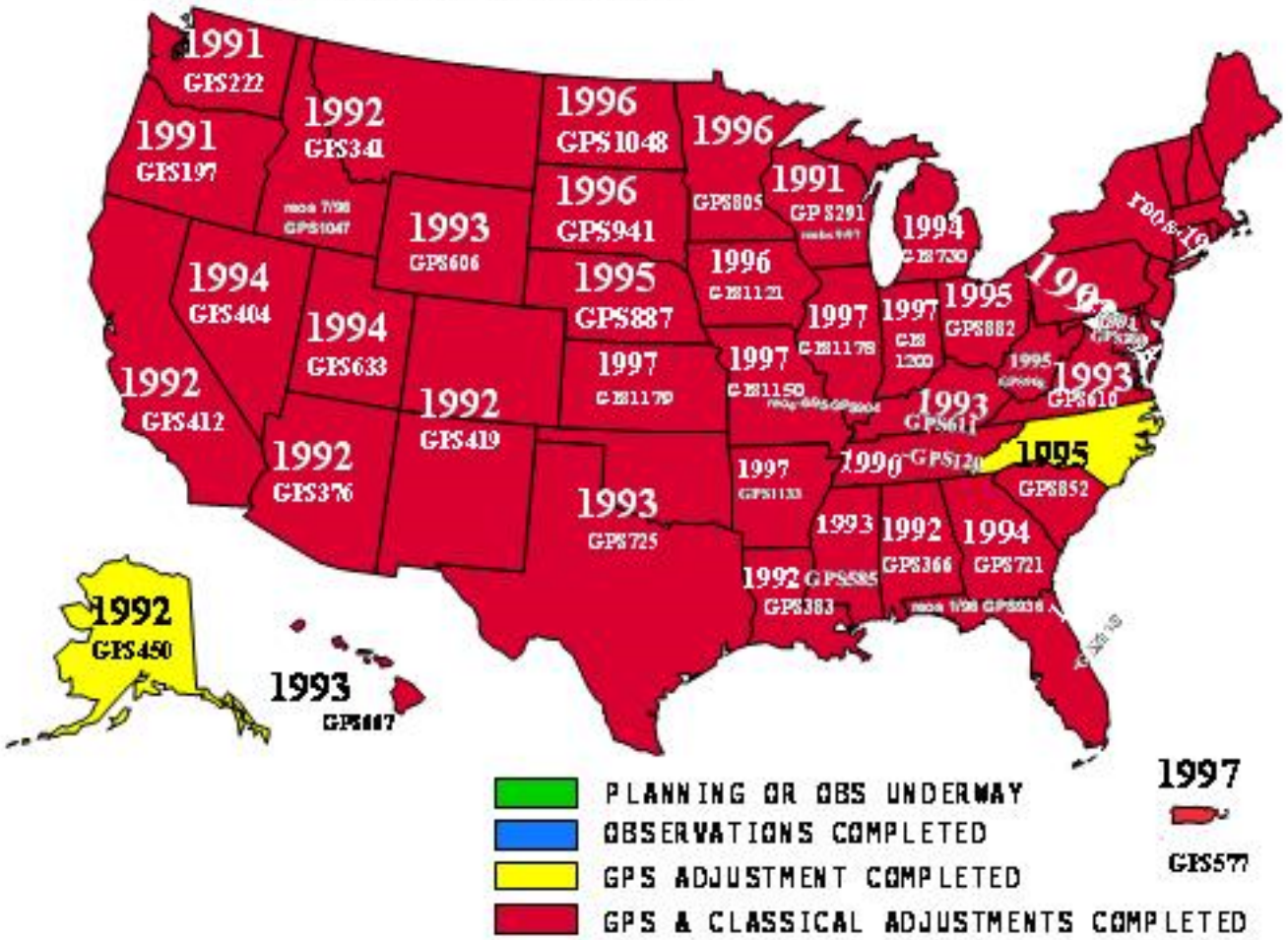
REMOVE DISTORTIONS IN EARLY HARNS (3-10 CM)

ENSURE CONNETIONS TO CORS

IMPROVE ELLIPSOID HEIGHT ACCURACY (Not worse than 2 cm)

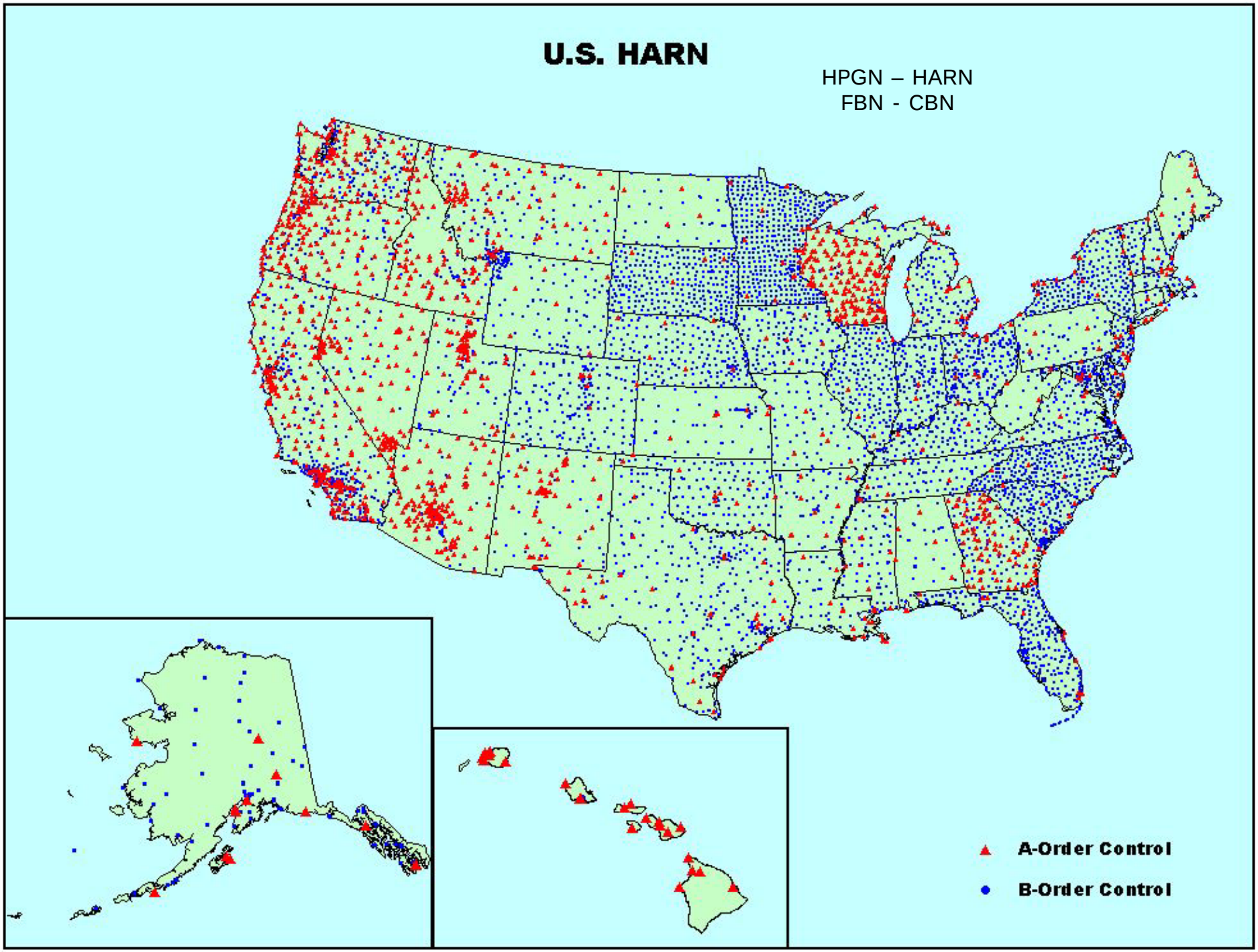
5/31/2005

FBN/CBN & STATEWIDE NETWORK STATUS



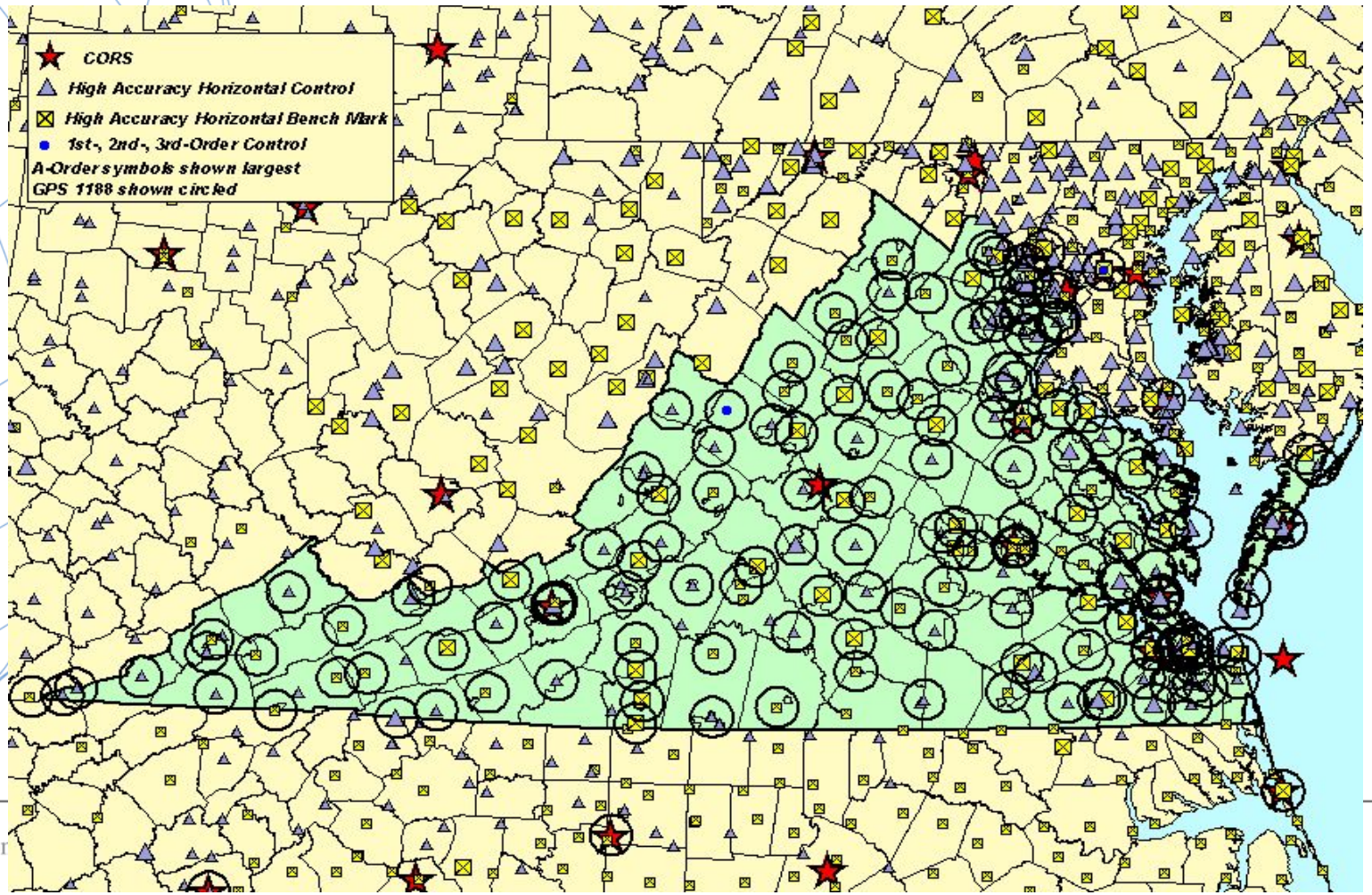
U.S. HARN

HPGN – HARN
FBN - CBN



VIRGINIA HARN
1993 & 2000

http://www.ngs.noaa.gov/PROJECTS/FBN/



NAD 83 National Readjustment

- Early GPS observations (prior to 1992) did not benefit from high accuracy GPS orbit data.
- Early GPS observations (prior to 1995) did not have access to CORS.
- HARN observations prior to 1997 did not focus on the vertical.
- Some HARNs exhibit 4 – 7 cm difference with CORS
- Different NAD 83 adjustment tags (e.g., NAD 83 1992, NAD 83 1997 etc.) in adjoining states causes confusion.

NAD 83 National Readjustment
NAD 83 (NSRS2007)

- **NOT a new datum.** A readjustment within the original NAD 83 framework
- GPS only – Classical (triangulation/traverse) was not included
- National CORS used as control -- NAD_83 (CORS96) (Epoch 2002.0)
- Coordinates adjusted and published for both NAD83 (NSRS 2007) and ITRF
- All GPS data submitted to NSRS was included
- Network and Local Accuracies computed
- No changes to NAD 83 State Plane Coordinate System parameters

NAD 83 National Readjustment

3436 Projects used

- Free Adjustment
- Outliers Rejected
- Connectivity to A/B Order Network Verified
- 67,693 Total Stations

NAD 83 "TRASH"

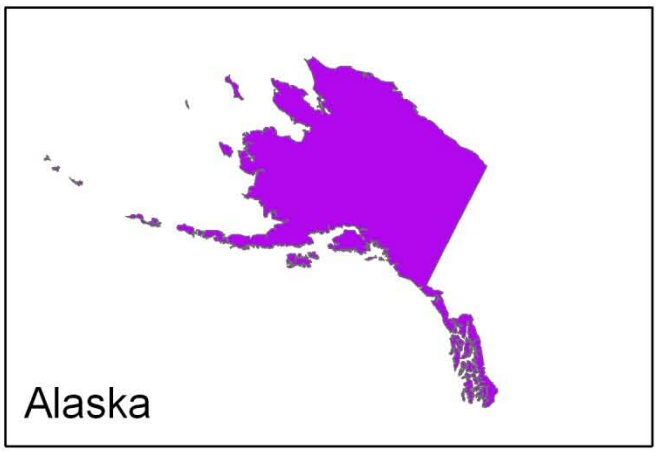
- **Projects Not Recommended for Inclusion**
  - **149 projects with 9903 stations**
  - **Many Third-Order FAA Projects from 1980's**
  - **Some projects that have no ties to the Network**
  - **Includes original TN HARN (Macrometer Data)**
  - **Included original Eastern Strain Network project**

NAD 83 NATIONAL READJUSTMENT

NAD 83 data that is NOT part of NSRS must be readjusted by contractor/user with original observations

NGS WILL NOT develop a transformation tool

NAD 83 Adjustment 2007 - Horizontal

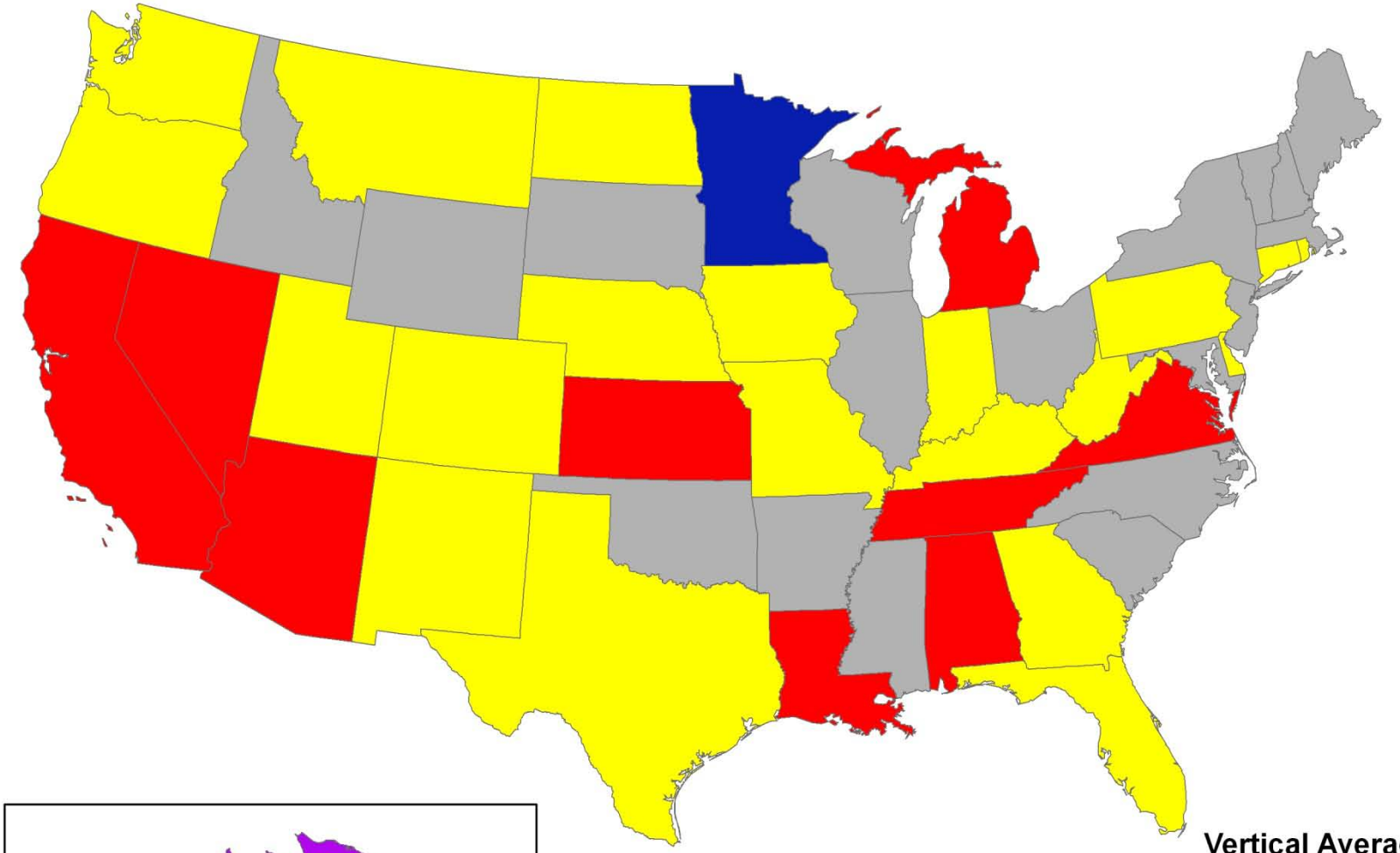


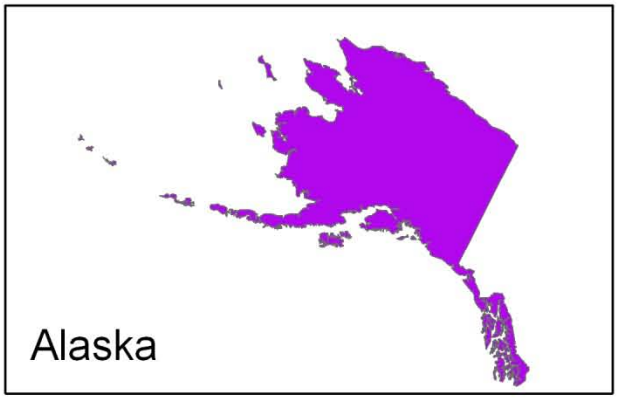
Horizontal Average Change (Meters)

- 0.008 - 0.014
- 0.015 - 0.025
- 0.026 - 0.043
- 0.044 - 0.109
- 0.110 - 0.204

Produced Feburary 12, 2007

NAD 83 Adjustment 2007 - Ellipsoid Height

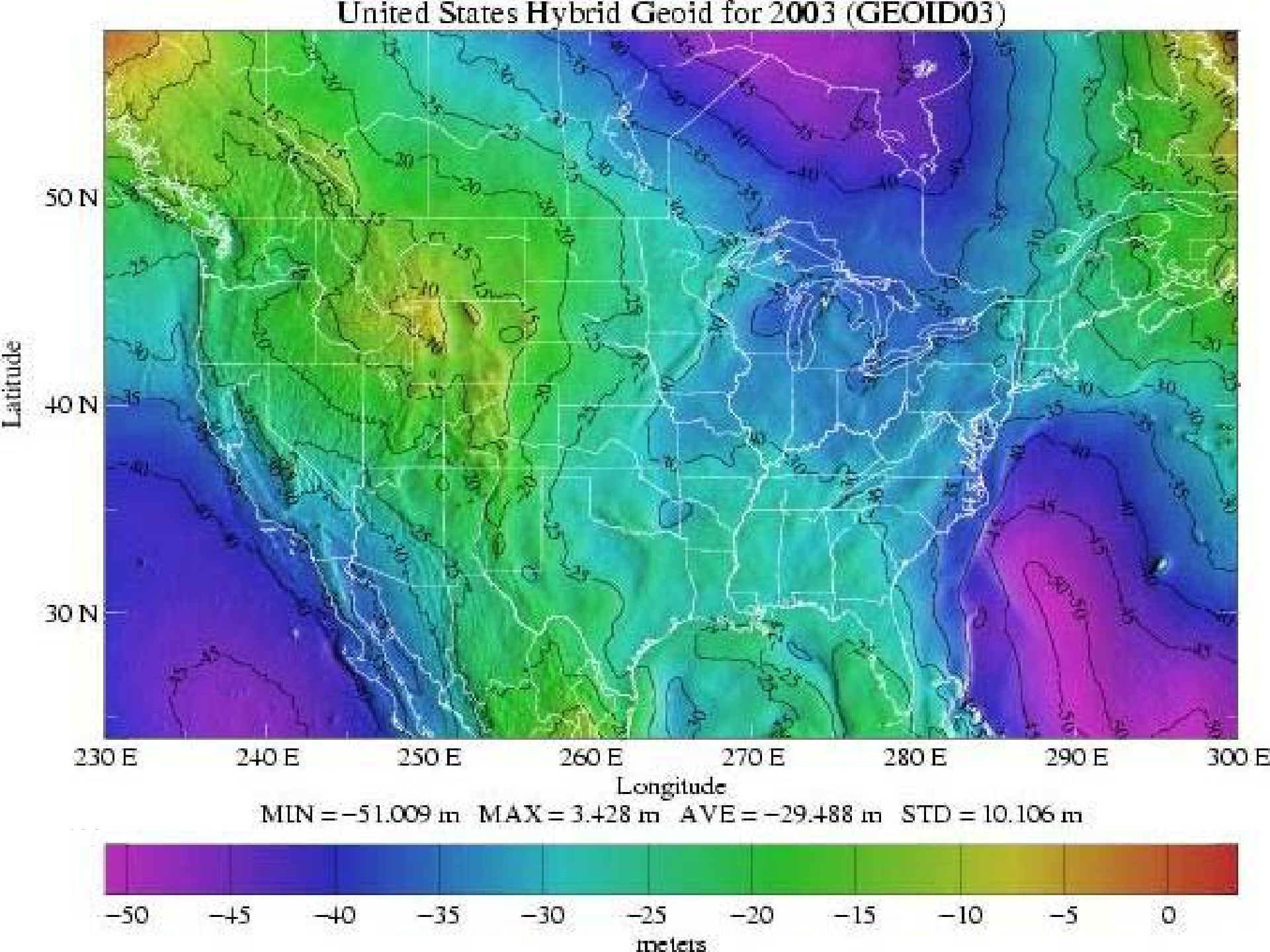


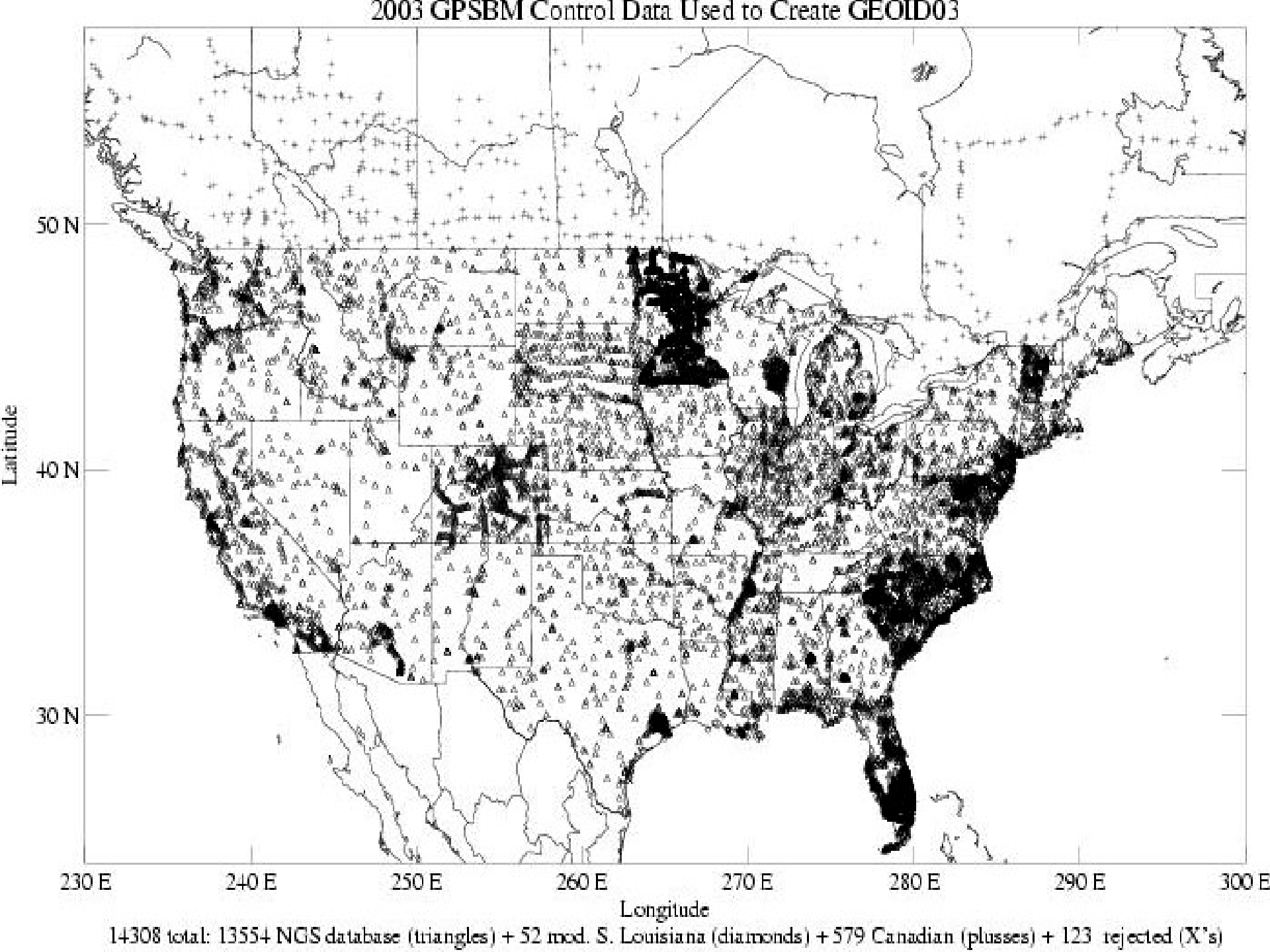


Vertical Average Change (Meters)

- 0.008 - 0.015
- 0.016 - 0.023
- 0.024 - 0.042
- 0.043 - 0.073
- 0.074 - 0.395

Produced Feburary 12, 2007


United States Hybrid Geoid for 2003 (GEOID03)
50 N
40 N
30 N
Latitude
230 E
240 E
250 E
260 E
270 E
280 E
290 E
300 E
Longitude
MIN = −51.009 m MAX = 3.428 m AVE = −29.488 m STD = 10.106 m
−50
−45
−40
−35
−30
−25
−20
−15
−10
−5
0
meters


2003 GPSBM Control Data Used to Create GEOID03
50 N
40 N
30 N
Latitude
230 E
240 E
250 E
260 E
270 E
280 E
290 E
300 E
Longitude
14308 total: 13554 NGS database (triangles) + 52 mod. S. Louisiana (diamonds) + 579 Canadian (plusses) + 123 rejected (X's)

FUTURE GEOID MODELS

National Geospatial-Intelligence Agency (NGA)
EGM08 – Released April, 2008
Estimate globally 20-50 cm

National Geodetic Survey
GEOID08 – End of FY 2008
Goal 2-4 cm (conterminous U.S.)

```
        National Geodetic Survey,   Retrieval Date = MAY  5, 2008
HV2896 ***********************************************************************
HV2896  DESIGNATION -  J 465
HV2896  PID         -  HV2896
HV2896  STATE/COUNTY-  VA/CAROLINE
HV2896  USGS QUAD   -
HV2896
HV2896                        *CURRENT SURVEY CONTROL
HV2896  ______________________________________________________________________
HV2896* NAD 83(2007)-  38 13 55.74085(N)    077 10 28.77702(W)     ADJUSTED
HV2896* NAVD 88     -       16.070  (meters)      52.72   (feet)  ADJUSTED
HV2896  ______________________________________________________________________
HV2896  EPOCH DATE  -        2002.00
HV2896  X           -   1,100,754.435 (meters)                     COMP
HV2896  Y           -  -4,894,253.692 (meters)                     COMP
HV2896  Z           -   3,925,707.327 (meters)                     COMP
HV2896  LAPLACE CORR-          -3.37  (seconds)                    DEFLEC99
HV2896  ELLIP HEIGHT-        -16.477 (meters)          (02/10/07) ADJUSTED
HV2896  GEOID HEIGHT-        -32.63  (meters)                     GEOID03
HV2896  DYNAMIC HT  -         16.061 (meters)      52.69  (feet)  COMP
HV2896
HV2896  ------- Accuracy Estimates (at 95% Confidence Level in cm) --------
HV2896  Type    PID    Designation                      North   East  Ellip
HV2896  ----------------------------------------------------------------------
HV2896  NETWORK HV2896 J 465                              1.10   0.96   1.57
HV2896  ----------------------------------------------------------------------
HV2896  MODELED GRAV-     980,029.5   (mgal)                       NAVD 88
HV2896
HV2896  VERT ORDER  -  FIRST     CLASS I
HV2896
HV2896.The horizontal coordinates were established by GPS observations
HV2896.and adjusted by the National Geodetic Survey in February 2007.
HV2896
HV2896.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
HV2896.See National Readjustment for more information.
HV2896.The horizontal coordinates are valid at the epoch date displayed above.
HV2896.The epoch date for horizontal control is a decimal equivalence
HV2896.of Year/Month/Day.
HV2896
HV2896.The orthometric height was determined by differential leveling
HV2896.and adjusted in June 1991.
HV2896
HV2896.The X, Y, and Z were computed from the position and the ellipsoidal ht.
HV2896
HV2896.The Laplace correction was computed from DEFLEC99 derived deflections.
HV2896
HV2896.The ellipsoidal height was determined by GPS observations
HV2896.and is referenced to NAD 83.
HV2896
```

$$H = h - N$$

$$16.07 = -16.48 - (-32.63)$$

$$16.07 \neq 16.15$$

```
HV2896.The modeled gravity was interpolated from observed gravity values.
HV2896
HV2896;                    North         East     Units Scale Factor Converg.
HV2896;SPC VA N     - 2,063,426.114 3,602,900.888   MT  0.99997086   +0 44 00.8
HV2896;SPC VA N     - 6,769,757.18 11,820,517.33   sFT  0.99997086   +0 44 00.8
HV2896;UTM  18      - 4,234,128.253   296,532.924   MT  1.00010988   -1 26 20.8
HV2896
HV2896!             -  Elev Factor  x  Scale Factor =   Combined Factor
HV2896!SPC VA N     -   1.00000259  x   0.99997086  =   0.99997345
HV2896!UTM  18      -   1.00000259  x   1.00010988  =   1.00011247
HV2896
HV2896                          SUPERSEDED SURVEY CONTROL
HV2896
HV2896  ELLIP H (05/17/02)  -16.562  (m)                        GP(       ) 4 2
HV2896  NAD 83(1993)-  38 13 55.74107(N)    077 19 28.77675(W) AD(       ) 1
HV2896  ELLIP H (10/09/01)  -16.554  (m)                        GP(       ) 4 1
HV2896  NAVD 88 (10/09/01)   16.07   (m)           52.7    (f) LEVELING    3
HV2896  NGVD 29 (??/??/??)   16.317  (m)           53.53   (f) ADJUSTED    1 1
HV2896
HV2896.Superseded values are not recommended for survey control.
HV2896.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
HV2896.See file dsdata.txt to determine how the superseded data were derived.
HV2896
HV2896_U.S. NATIONAL GRID SPATIAL ADDRESS: 18STH9653334128(NAD 83)
HV2896_MARKER: DB = BENCH MARK DISK
HV2896_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
HV2896_SP_SET: SET IN TOP OF CONCRETE MONUMENT
HV2896_STAMPING: J 465 1971
HV2896_MARK LOGO: NONE
HV2896_MAGNETIC: N = NO MAGNETIC MATERIAL
HV2896_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
HV2896+STABILITY: SURFACE MOTION
HV2896_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
HV2896+SATELLITE: SATELLITE OBSERVATIONS - October 04, 2006
HV2896
HV2896  HISTORY     - Date     Condition        Report By
HV2896  HISTORY     - 1971     MONUMENTED       NGS
HV2896  HISTORY     - 1972     GOOD             NGS
HV2896  HISTORY     - 1978     GOOD             DMA
HV2896  HISTORY     - 19950831 GOOD             USPSQD
HV2896  HISTORY     - 20000926 GOOD             GEOMET
HV2896  HISTORY     - 20020116 GOOD             USPSQD
HV2896  HISTORY     - 20061004 GOOD             USPSQD
```

CONTINUOUSLY OPERATING REFERENCE STATIONS (CORS)

1300+ Installed and Operated by various Federal-State-local Agencies

NOAA / National Geodetic Survey
NOAA / OAR Global Systems Divisic
U.S. Coast Guard - DGPS / NDGPS
Corps of Engineers - DGPS
FAA - WAAS / LAAS
State DOTs
County and City
Academia
Private Companies

CONTINUOUSLY OPERATING REFERENCE STATIONS (CORS)

Dual-Frequency Antennas and Receivers

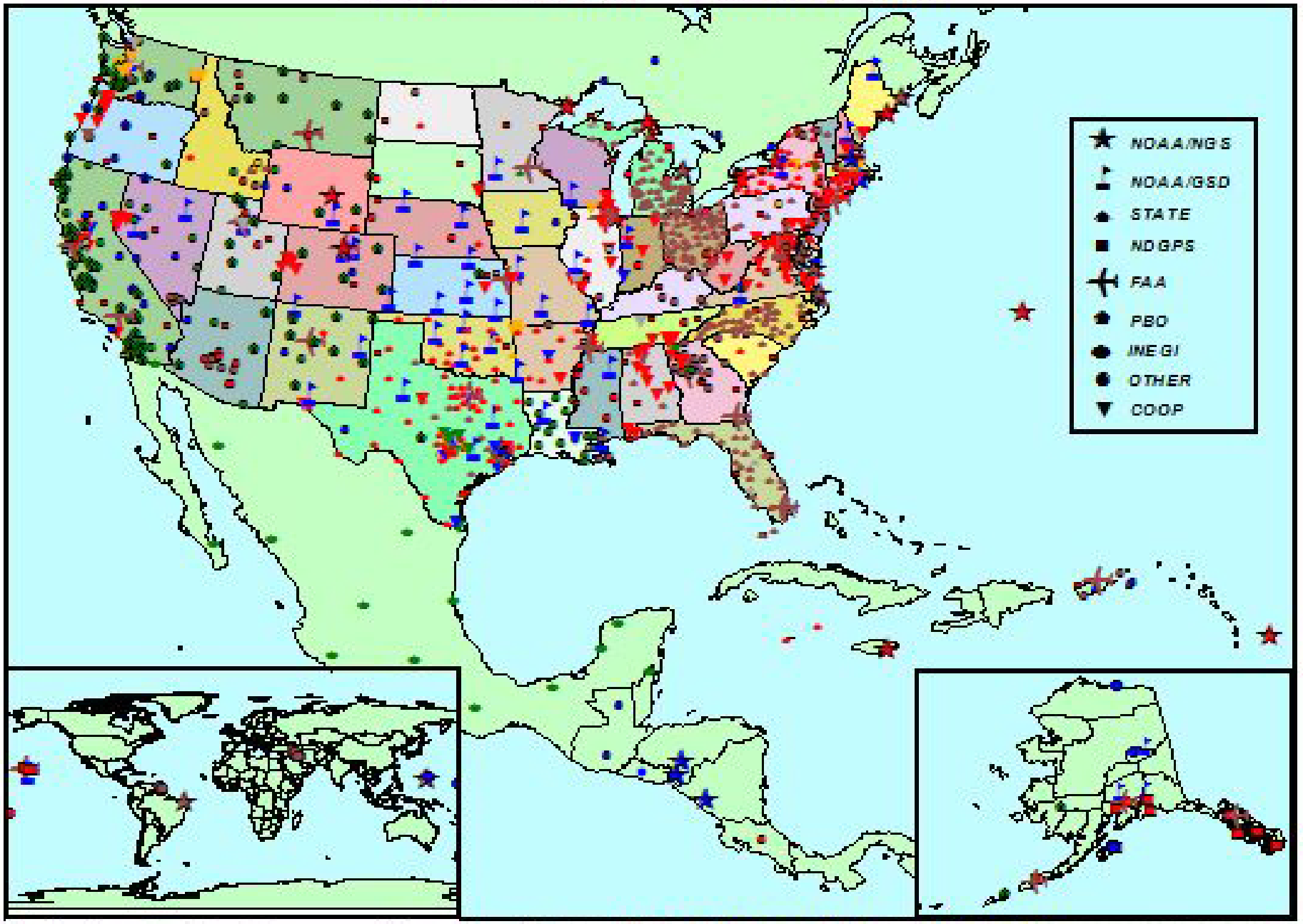
Allen-Osborne
Ashtech
Leica
Topcon
Trimble

CONTINUOUSLY OPERATING REFERENCE STATIONS (CORS)

NGS PROVIDES

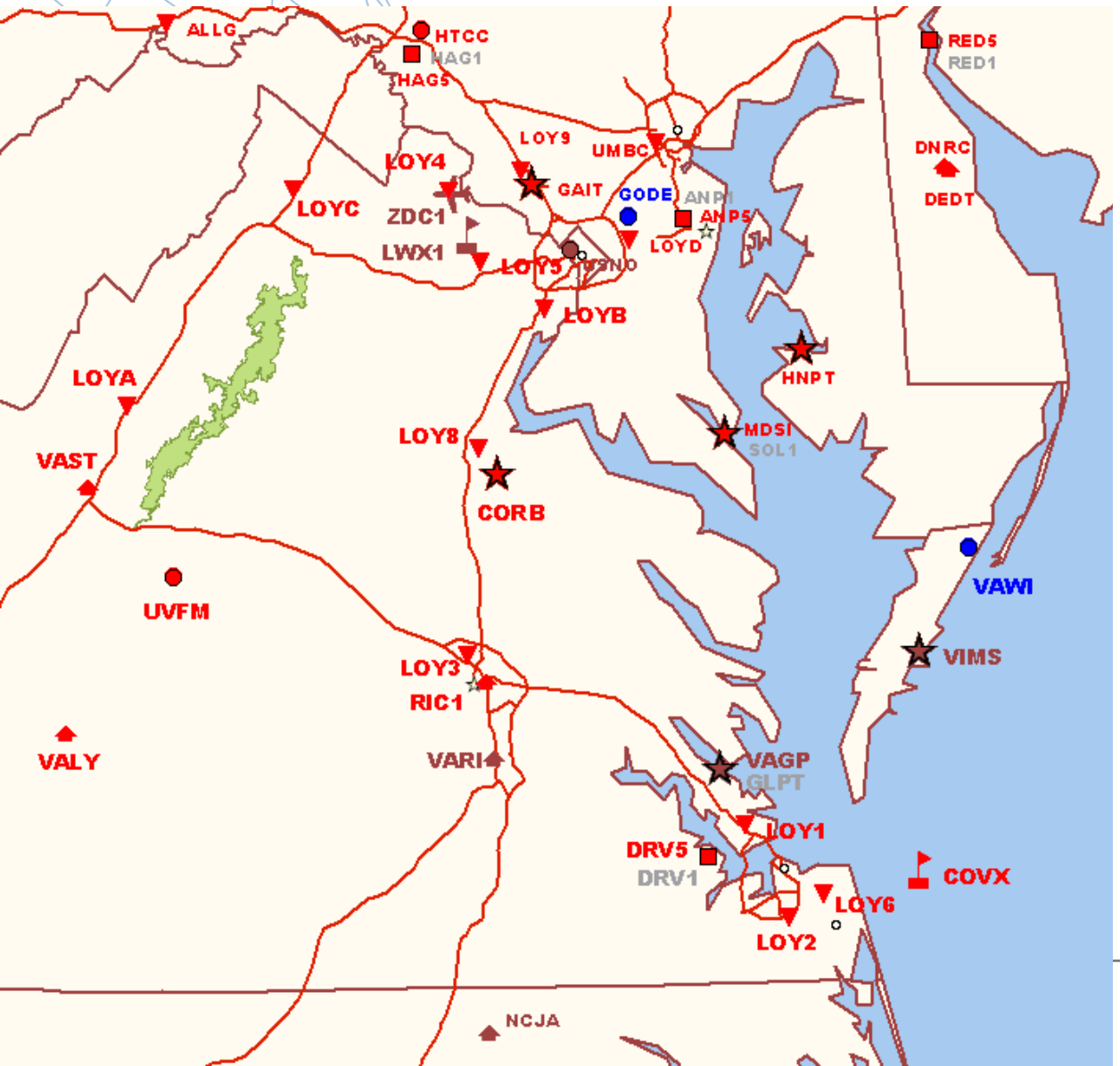
Horizontal and Vertical NSRS Connections
NAD 83 and ITRF00 Coordinates
Network Data Collection - Hourly & Daily
Daily 3D Network Integrity Adjustment
Public Data Distribution - Internet
14 Year On-Line Data Holding

CORS Coverage



Symbol color denotes sampling rates: (1 sec) (5 sec) (10 sec) (15 sec) (30 sec) (Decommissioned)

REGIONAL CORS NETWORK



Operator:

- *NOAA/NGS*
- *NOAA/GSD*
- *STATE*
- *NDGPS*
- *FAA*
- *PBO*
- *INEGI*
- *OTHER*
- *COOP*

Sampling Rate:

- *1 second*
- *5 seconds*
- *10 seconds*
- *15 seconds*
- *30 seconds*
- *Decommissioned*

CORBIN (CORB), VIRGINIA

Antenna Reference Point(ARP): CORBIN CORS ARP

PID = AJ2122

ITRF00 POSITION (EPOCH 1997.0)
Transformed from ITRF97 position in Nov. 2001.

X =	1097041.441 m	latitude =	38 12 07.85567 N
Y =	-4897238.428 m	longitude =	077 22 24.57954 W
Z =	3923126.231 m	ellipsoid height =	35.938 m

ITRF00 VELOCITY
Transformed from ITRF97 velocity in Nov. 2001.

VX =	-0.0161 m/yr	northward =	0.0032 m/yr
VY =	-0.0018 m/yr	eastward =	-0.0161 m/
VZ =	0.0027 m/yr	upward =	0.0003 m/

NAD_83 POSITION (EPOCH 2002.0)
Transformed from ITRF00 (epoch 1997.0) position in Mar. 2002.

X =	1097041.982 m	latitude =	38 12 07.82819 N
Y =	-4897239.901 m	longitude =	077 22 24.57106 W
Z =	3923126.377 m	ellipsoid height =	37.252 m

NAD_83 VELOCITY
Transformed from ITRF00 velocity in Mar. 2002.

VX =	0.0000 m/yr	northward =	0.0000 m/yr
VY =	-0.0001 m/yr	eastward =	0.0000 m/yr
VZ =	0.0000 m/yr	upward =	0.0000 m/yr

ITRF00 – NAD 83(CORS96)
ΔHoriz = 0.872m
ΔEHt = 1.314m

WHAT YOU NEED TO USE THE STATE PLANE and UTM COORDINATE SYSTEMS

N & E State Plane Coordinates for Control Points

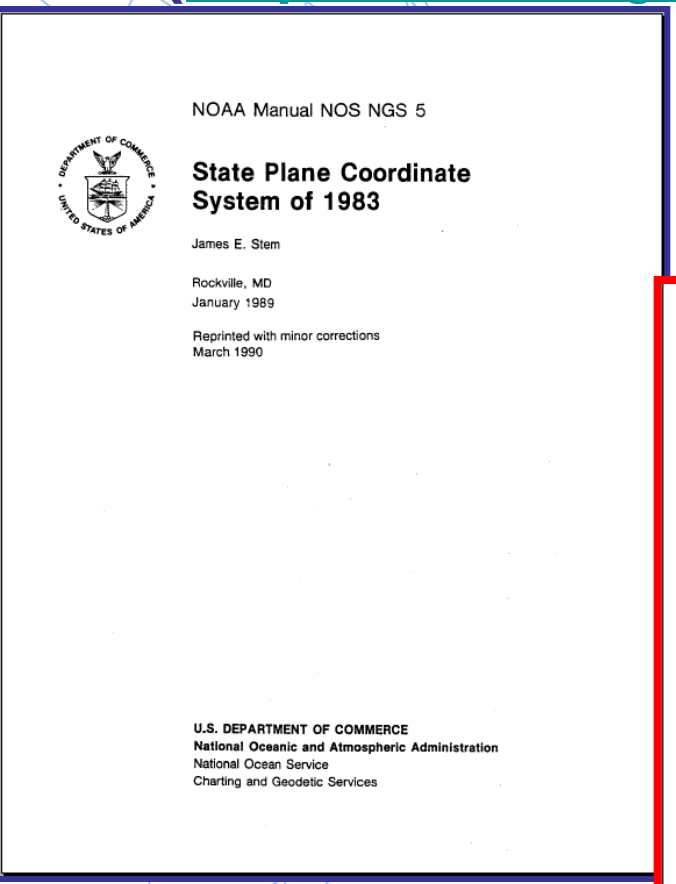
AZIMUTHS

- "True" (Astronomic), Geodetic, or Grid
- Conversion from Astronomic to Geodetic
- Conversion from Geodetic to Grid (Mapping Angle)

DISTANCES

- Reduction from Horizontal to Ellipsoid
  "Sea-Level Reduction Factor"
- Correction for Grid Scale Factor
- Combined Factor

STATE PLANE COORDINATE MANUALS (http://www.ngs.noaa.gov/PUBS_LIB/pub_index.html)



NOAA Manual NOS NGS 5

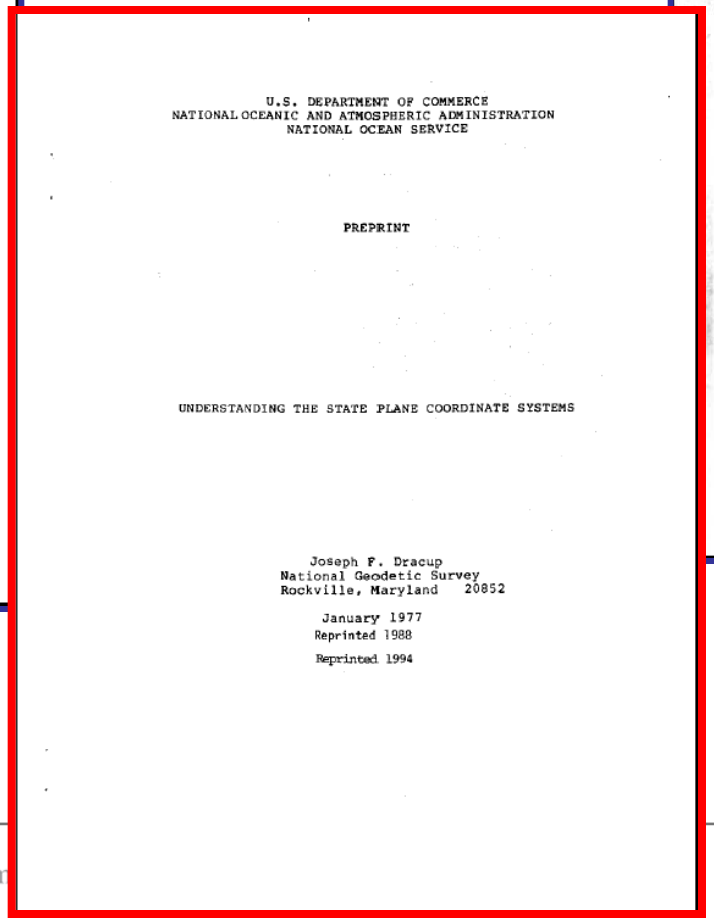
State Plane Coordinate System of 1983

James E. Stem

Rockville, MD
January 1989

Reprinted with minor corrections
March 1990

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Charting and Geodetic Services



U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

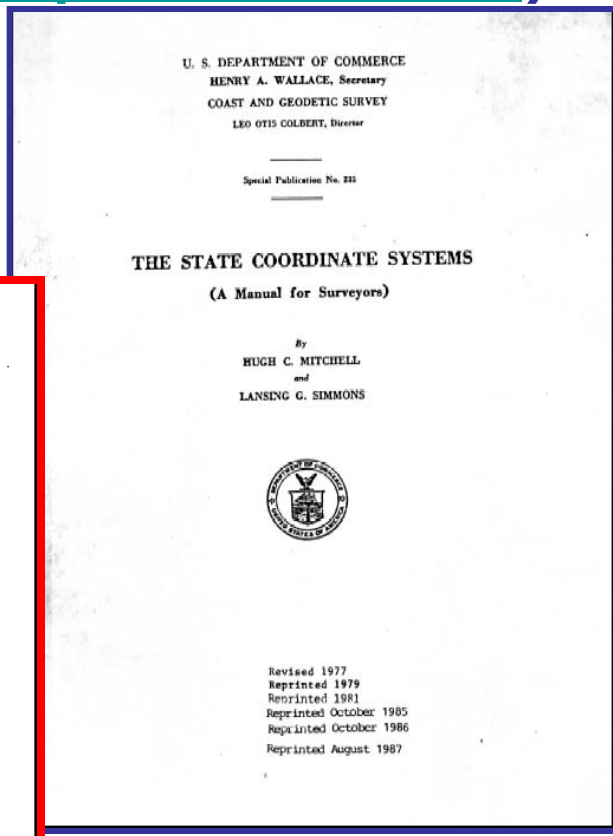
PREPRINT

UNDERSTANDING THE STATE PLANE COORDINATE SYSTEMS

Joseph F. Dracup
National Geodetic Survey
Rockville, Maryland 20852

January 1977
Reprinted 1988

Reprinted 1994



U. S. DEPARTMENT OF COMMERCE
HENRY A. WALLACE, Secretary
COAST AND GEODETIC SURVEY
LEO OTIS COLBERT, Director

Special Publication No. 235

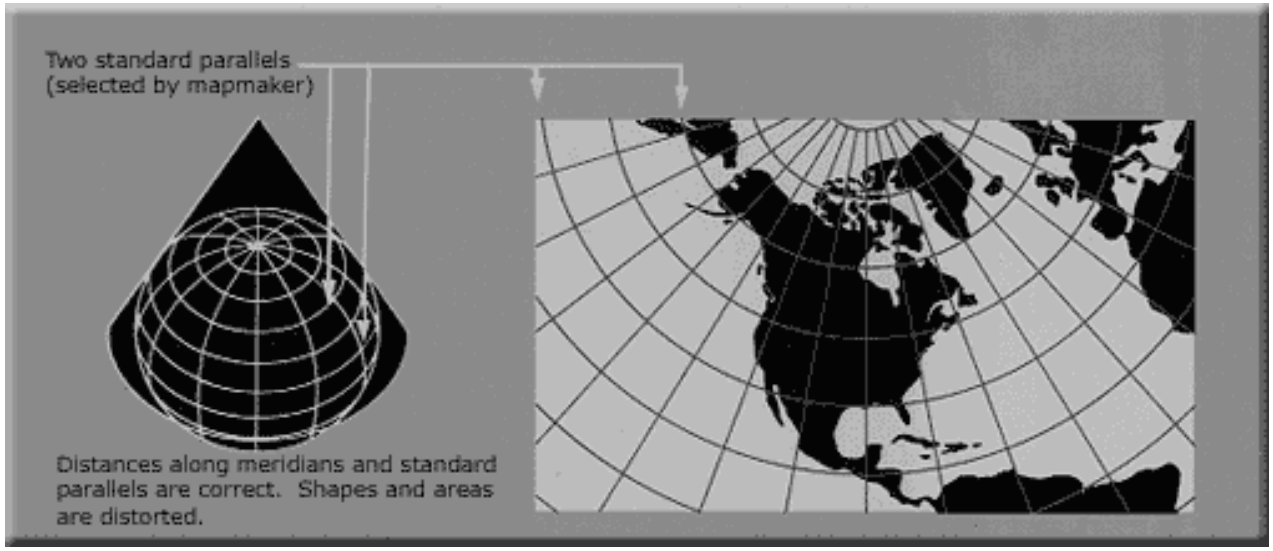
THE STATE COORDINATE SYSTEMS
(A Manual for Surveyors)

By
HUGH C. MITCHELL
and
LANSING G. SIMMONS

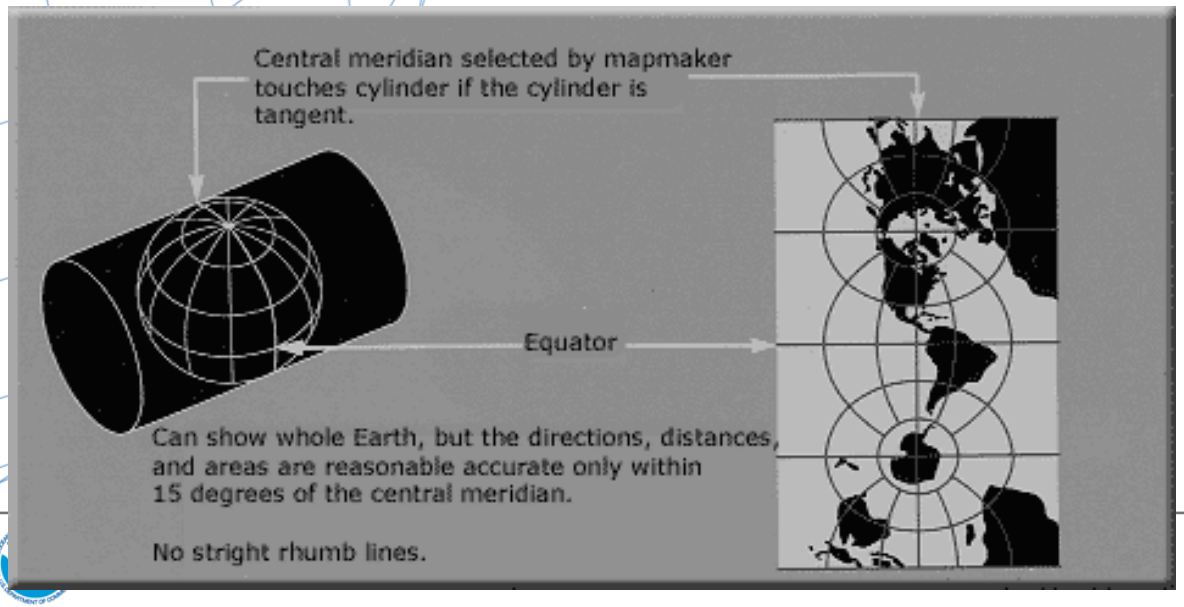
Revised 1977
Reprinted 1979
Reprinted 1981
Reprinted October 1985
Reprinted October 1986
Reprinted August 1987

MAP PROJECTIONS

Lambert Conformal Conic



Transverse Mercator



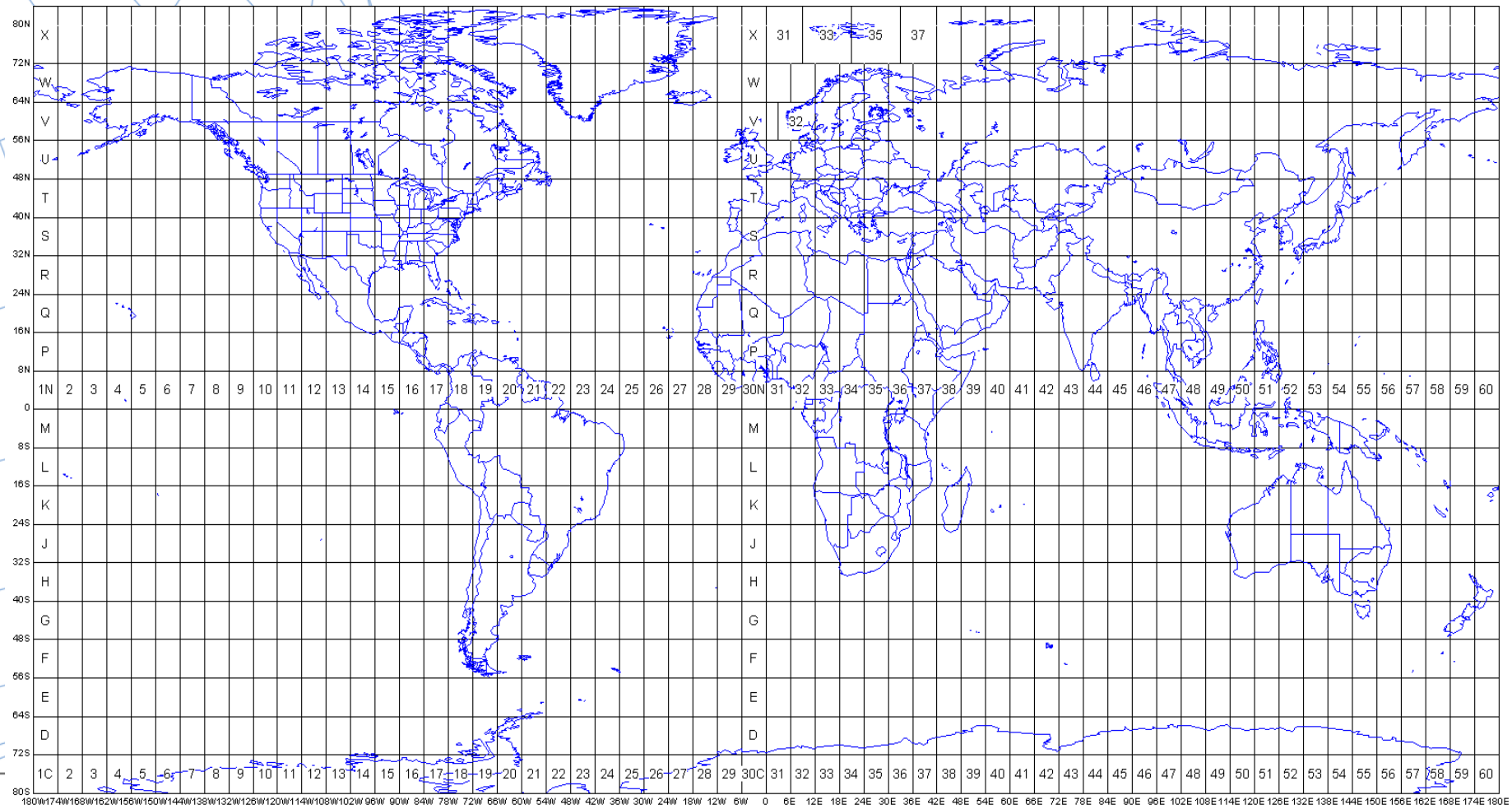
UNIVERSAL TRANSVERSE MERCATOR (UTM)

The Universal Grids: Universal Transverse Mercator (UTM) and Universal Polar Stereographic (UPS) - TM8358.2
http://earth-info.nga.mil/GandG/publications/tm8358.2/TM8358_2.pdf

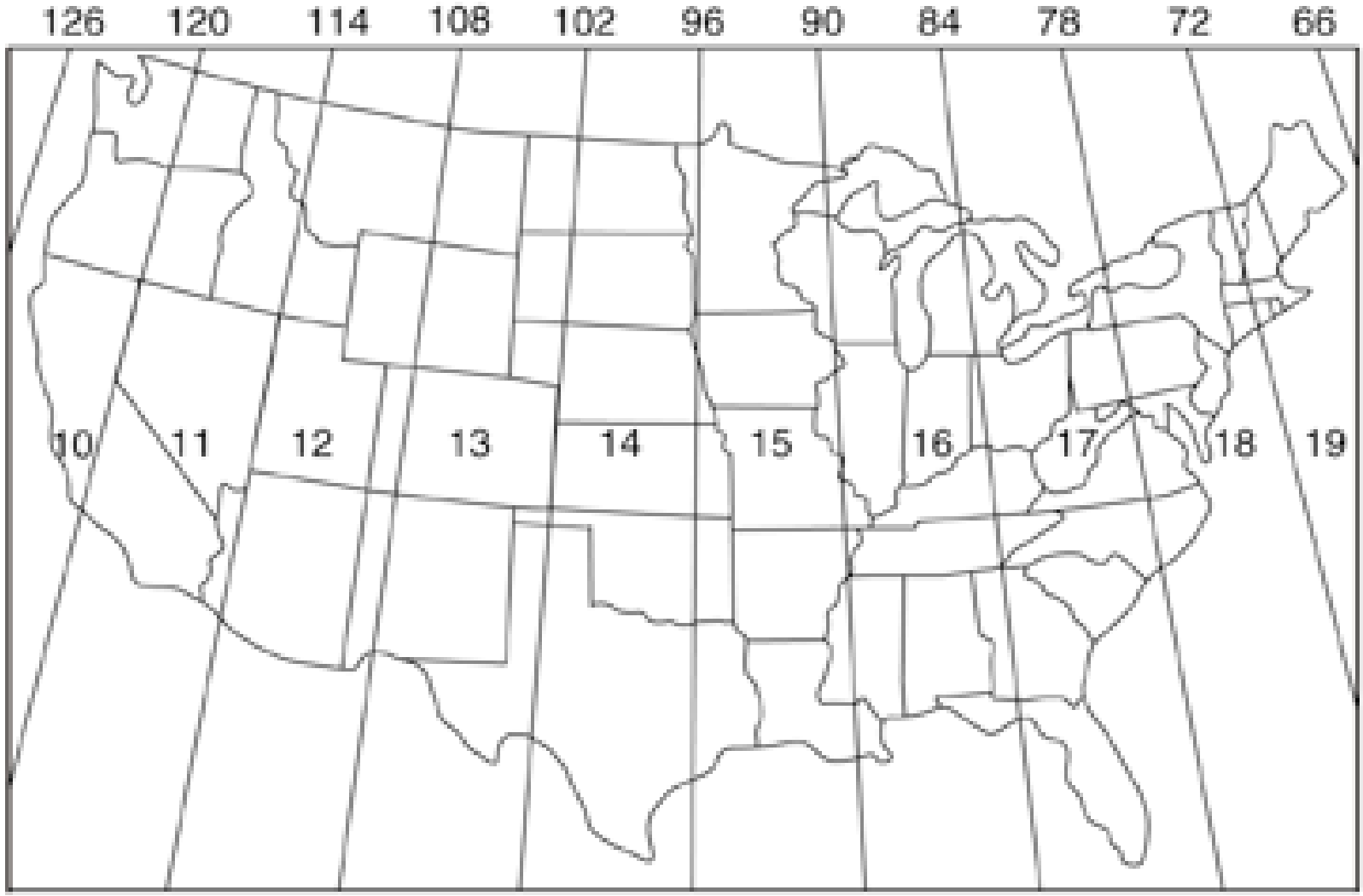
Transverse Mercator Projection

- Zones 6º Longitude World-Wide
- Northing Origin (0 meters- N Hemisphere) at the Equator
- Easting Origin (500,000 meters) at Central Meridian of Each Zone
- NAD 27 and NAD 83 both defined in meters
- NAD 27 to NAD 83 shift = 200-225 meters for U.S.

UNIVERSAL TRANSVERSE MERCATOR (UTM)



UNIVERSAL TRANSVERSE MERCATOR (UTM)



STATE PLANE COORDINATE SYSTEMS

Developed by USC&GS in 1933

Lambert Conformal Conic and Transverse Mercator Projections

(Except AK Zone 1, Guam and American Samoa)

International, State and County Boundaries
Zones originally (1933) limited to about 158 miles wide

NAD 27 – Coordinates only in U.S. Survey Feet

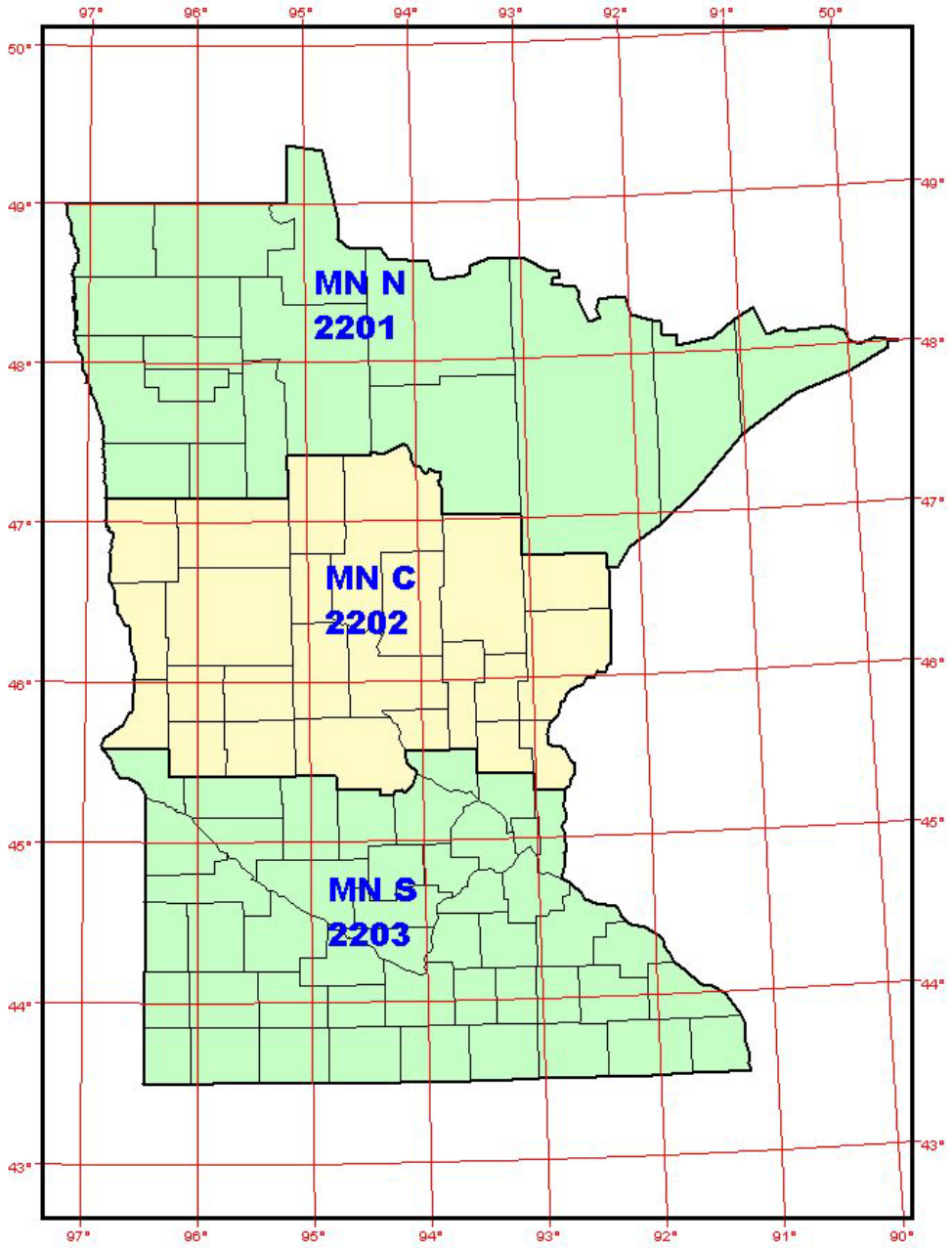
NAD 83 - Coordinates Metric w/State Defined Foot Conversion

1 Meter = 3.280833333 U.S. Survey Feet
1 Meter = 3.280839895 International Feet

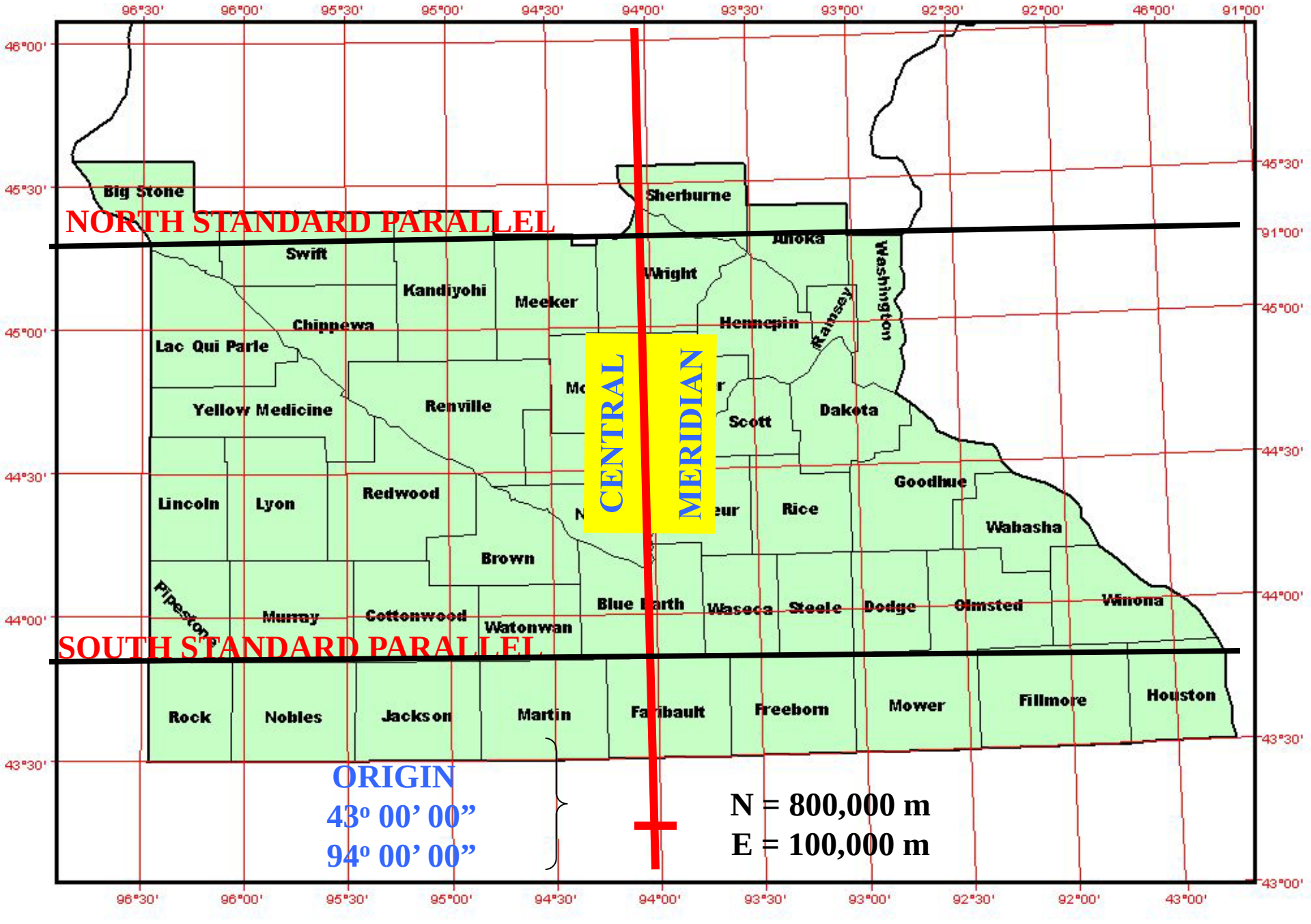
NAD 27 to NAD 83 VERY large Positional Shifts

STATE PLANE COORDINATE SYSTEMS

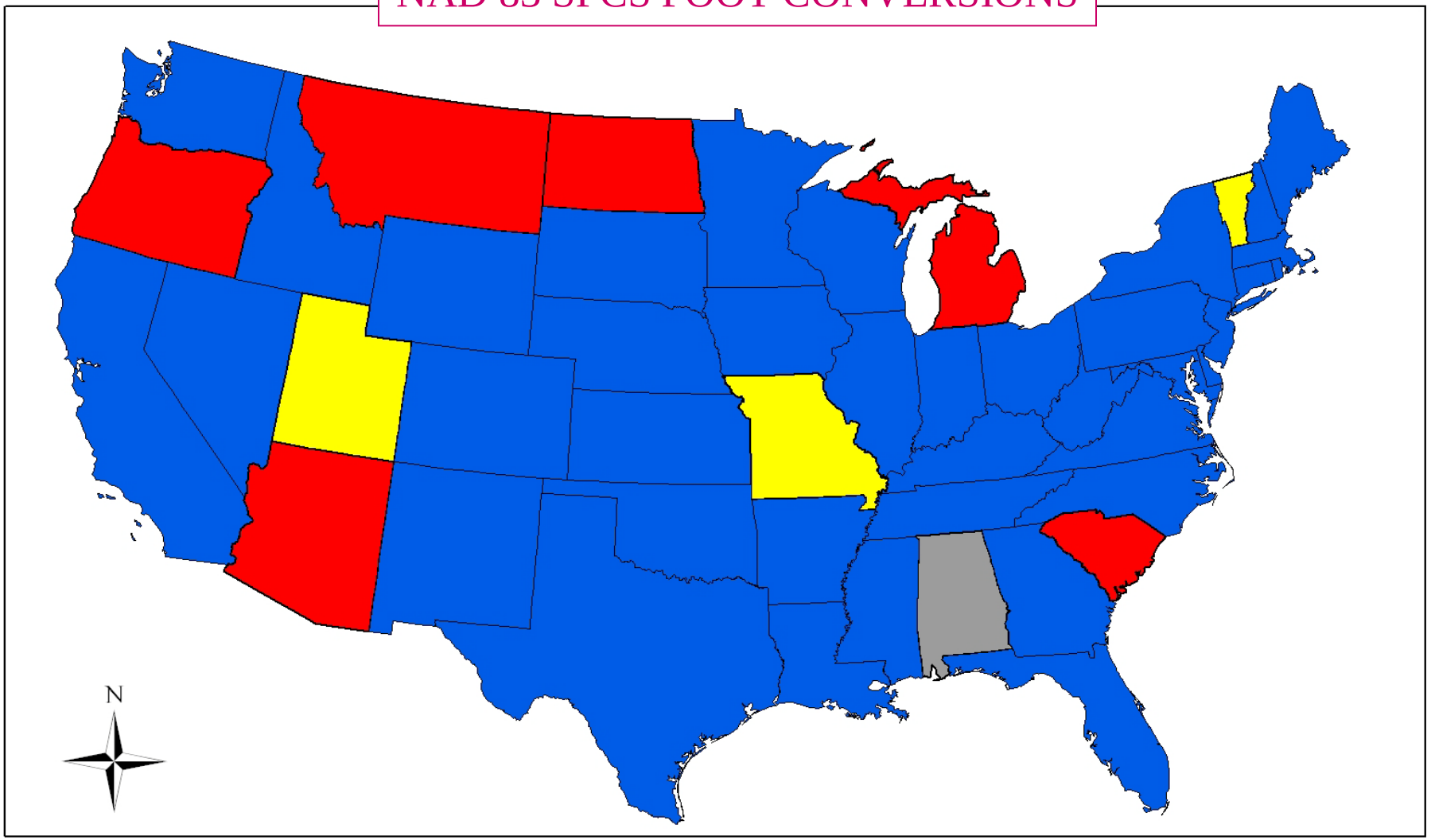
Minnesota State Plane Coordinate Zones



Minnesota South Zone - 2203



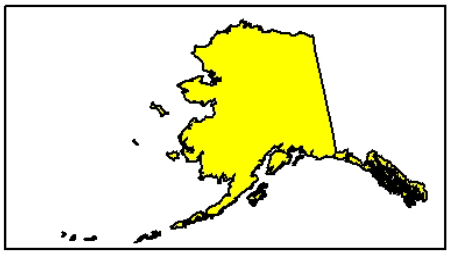
NAD 83 SPCS FOOT CONVERSIONS

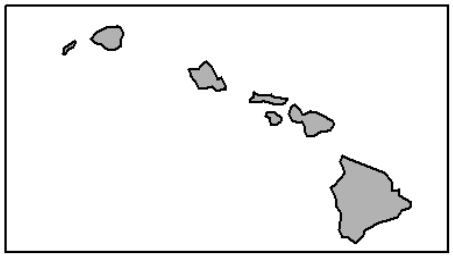


NAD 83 Legislation

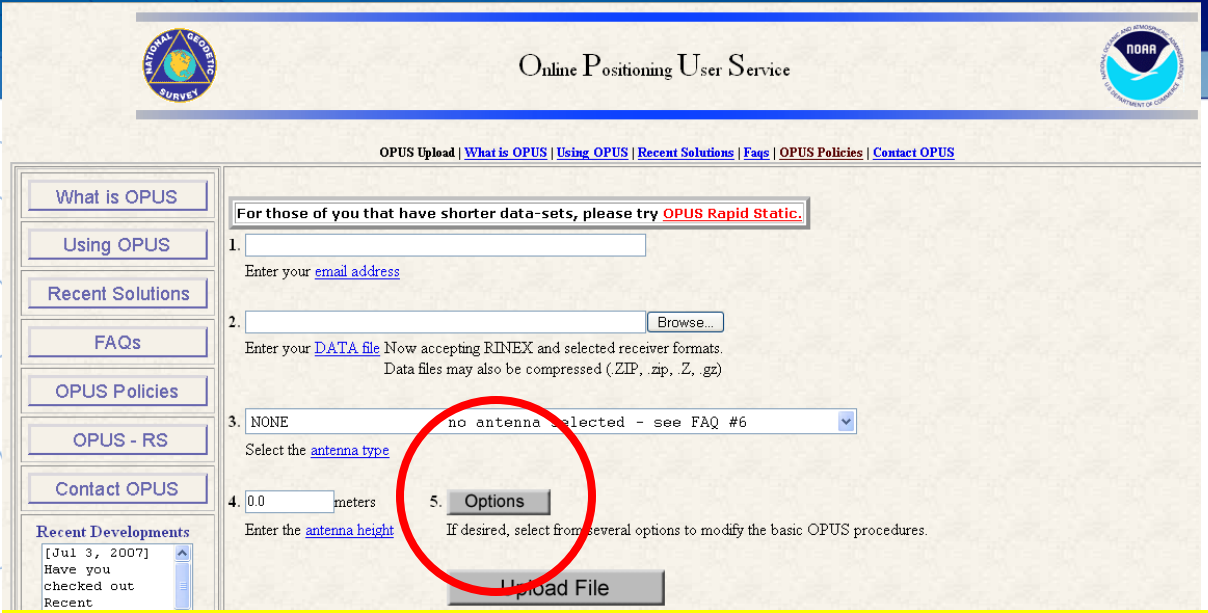
- No NAD 83 Legislation
- Foot Conversion Not Defined
- International Feet Defined
- U.S. Survey Foot Defined

Map Created
January 15, 2008





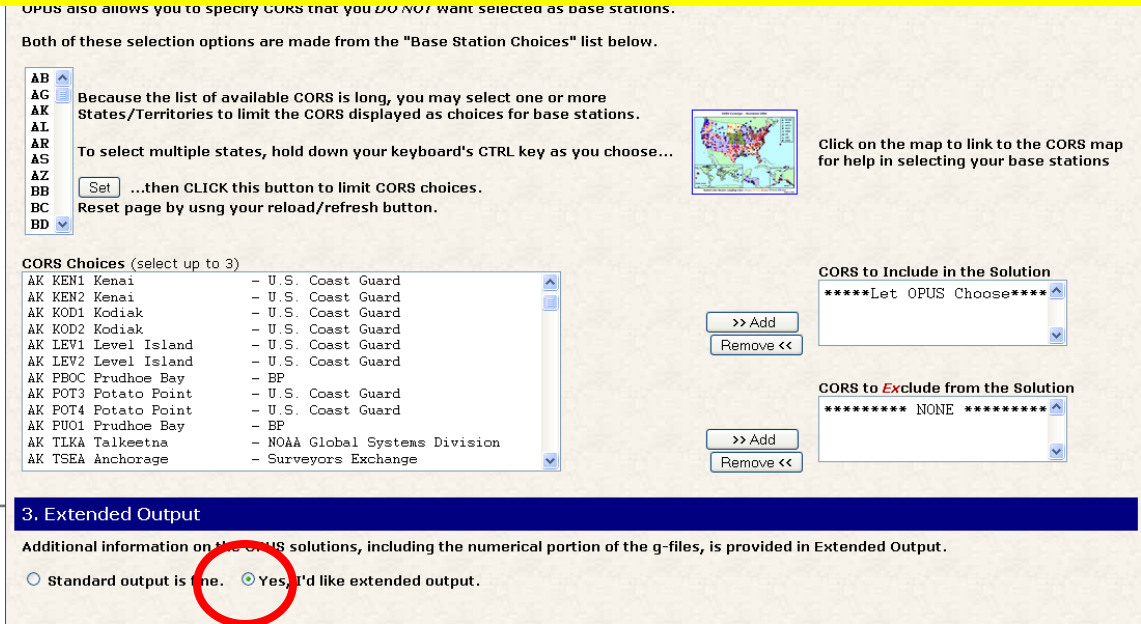
N.T.S



SPCs in Ft are provided on all NGS passive control datasheets

For the OPUS utility they are only provided if you request the extended output.

#3 on the OPUS Options page



National Oceanic and Atmospheric Administration

GROUND LEVEL COORDINATES
"IF YOU DO"

TRUNCATE COORDINATE VALUES

SUCH AS:

N = 13,750,260.07 ft becomes 50,260.07

E = 2,099,440.89 ft becomes 99,440.89

AND

DOCUMENT DOCUMENT DOCUMENT !!

DATUM TRANSFORMATIONS

1. WHAT DATUM ARE THE EXISTING COORDINATES ON?
2. WHAT DATUM DO I WANT THE NEW COORDINATES ON?
3. HOW LARGE A GEOGRAPHICAL AREA DO I WANT TO CONVERT AT ONE TIME?
4. HOW MANY POINTS ARE COMMON TO BOTH DATUMS?
5. WHAT IS THE DISTRIBUTION OF THE COMMON POINTS?
6. HOW ACCURATE ARE THE EXISTING COORDINATES?

   0.1 Foot
   1.0 Foot
   10. Feet

7. HOW ACCURATE DO I WANT THE NEW COORDINATES?

DATUM TRANSFORMATIONS

MOLODENSKY

Converts latitude, longitude and ellipsoidal height to X,Y,Z Earth-Centered Coordinates.

Applies a 3-dimensional change in the origin (dX, dY,dZ)

Applies a change in the size and shape of the reference ellipsoid

Converts new X,Y,Z Earth-Centered Coordinates back to latitude, longitude and ellipsoidal height

DATUM TRANSFORMATIONS

MOLODENSKY

For continental regions accuracy can be +/- 8 to 10 meters

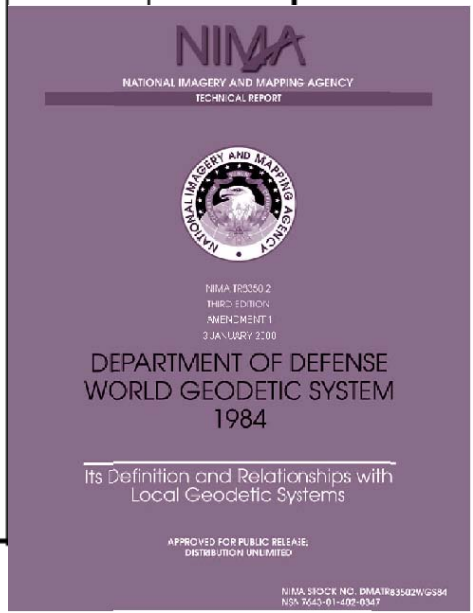
Does not model network distortions very well.

Assumes heights in both systems are ellipsoidal (NAD 27 did not have ellipsoidal heights).

Appendix B.6
Transformation Parameters
Local Geodetic Datums to WGS 84

Continent: NORTH AMERICA

Local Geodetic Datums		Reference Ellipsoids and Parameter Differences			No. of Satellite Stations Used	Transformation Parameters				
Name	Code	Name	Δa(m)	Δf x 10^4		Cycle Number	Pub. Date	ΔX(m)	ΔY(m)	ΔZ(m)
NORTH AMERICAN 1927 (cont'd)	NAS	Clarke 1866	-69.4	-0.37264639						
Eastern United States (Alabama, Connecticut, Delaware, District of Columbia, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, Virginia, West Virginia and Wisconsin)	NAS-A				129	0	1991	-9 ±5	161 ±5	179 ±8

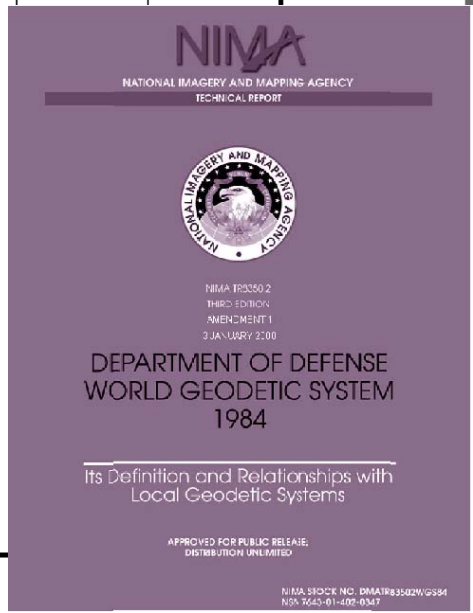


Appendix B.6

Transformation Parameters

Local Geodetic Datums to WGS 84

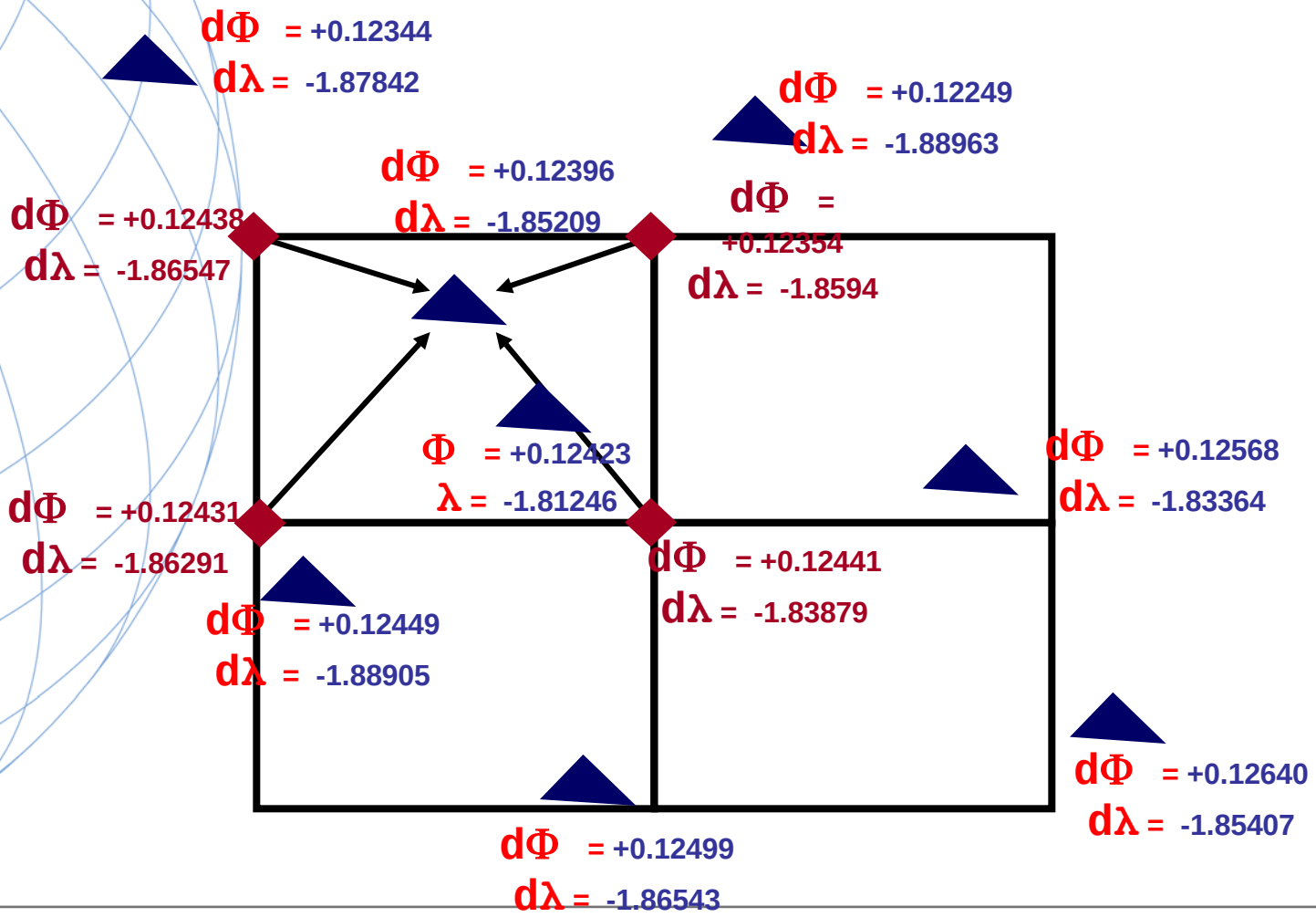
Continent: NORTH AMERICA										
Local Geodetic Datums		**Reference Ellipsoids and Parameter Differences**			**No. of Satellite Stations Used**	**Transformation Parameters**				
Name	**Code**	**Name**	**Δa(m)**	**Δf x 10^4**		**Cycle Number**	**Pub. Date**	**ΔX(m)**	**ΔY(m)**	**ΔZ(m)**
NORTH AMERICAN 1927 (cont'd)	NAS	Clarke 1866	-69.4	-0.37264639						
Eastern United States (Alabama, Connecticut, Delaware, District of Columbia, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, Virginia, West Virginia and Wisconsin)	NAS-A				129	0	1991	-9 ±5	161 ±5	179 ±8



DATUM TRANSFORMATION – IDEAL METHOD

- SATISFIES ALL USERS' REQUIREMENTS
- CAPABLE OF TRANSFORMING LARGE DATA SETS
- NEAR-REAL TIME APPLICATIONS
- SIMPLE - METHOD SHOULD NOT REQUIRE AN EXPERT OR DECISIONS TO BE MADE
- ACCURATE

NADCON


dΦ = +0.12344
dλ = -1.87842
dΦ = +0.12249
dλ = -1.88963
dΦ = +0.12396
dλ = -1.85209
dΦ = +0.12438
dλ = -1.86547
dΦ = +0.12354
dλ = -1.8594
Φ = +0.12423
λ = -1.81246
dΦ = +0.12568
dλ = -1.83364
dΦ = +0.12431
dλ = -1.86291
dΦ = +0.12441
dλ = -1.83879
dΦ = +0.12449
dλ = -1.88905
dΦ = +0.12640
dλ = -1.85407
dΦ = +0.12499
dλ = -1.86543

COORDINATE COMPARISON
NAD 27 to NAD 83 (2007)
MOLODENSY

ADJUSTED vs. TRANSFORMED

Station: ASTRO WEST PIER (HV3124)

LATITUDE	LONGITUDE	
38-12-07.39550	077-22-24.36090	- PUBLISHED
38-12-07.18787	077-22-24.35106	- MOLODENSKY
.20763”	.00984”	
6.402 m	0.239 m	

THIS CORRESPONDS TO A POSITIONAL DIFFERENCE OF 6.406 m (21.02 ft)

COORDINATE COMPARISON
NAD 27 to NAD 83 (2007)

NADCON

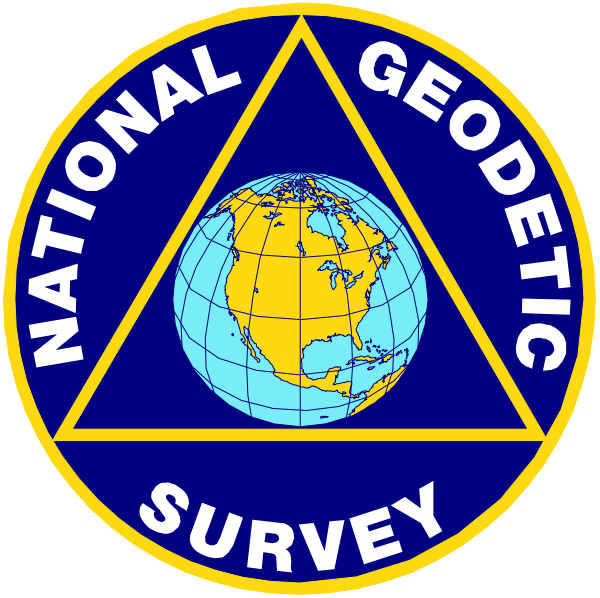
ADJUSTED vs. TRANSFORMED

Station: ASTRO WEST PIER (HV3124)

LATITUDE	LONGITUDE	
38-12-07.39550	077-22-24.36090	- PUBLISHED
38-12-07.39668	077-22-24.35705	- NADCON
.00118”	.00385”	
0.036 m	0.094 m	

THIS CORRESPONDS TO A POSITIONAL DIFFERENCE OF 0.101 m (0.33 ft)

GOOD COORDINATION BEGINS WITH GOOD COORDINATES



GEOGRAPHY WITHOUT GEODESY IS A FELONY