"Joy of Geodetics"

Part I

Introduction to Geodetic Survey Markers, and the NGS / USPS Recovery Program

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United States Power Squadrons / America's Boating Club
Sponsor: USPS Cooperative Charting Committee

Revision 5 - 2020

Part I - Topics Outline

1. USPS Geodetic Marker Program
2. What are Geodetic Markers
3. Marker Recovery & Reporting Steps
4. Coast Survey, NGS, and NOAA
5. Geodetic Datums & Control Types
6. How did Markers get Placed
7. Surveying Methods Used
8. The National Spatial Reference System
9. CORS Modernization Program

Do you enjoy

- Finding lost treasure?

- the excitement of the hunt?

- performing a valuable public service?

- participating in friendly competition?

- or just doing a really fun off-water activity?

If yes , then participation in the

USPS Geodetic Marker Recovery Program

may be just the thing for you!

The USPS Triangle and Civic Service Activities

- Public Boating Courses
- Vessel Safety Checks
- Waterway Clean-Ups
- Boat Shows
- Coop Charting - Nautical
- Coop Charting - Geodetic

USPS Cooperative Charting / Geodetic Programs

The Cooperative Charting Program (Nautical) and the Geodetic Marker Recovery Program (Land Based) are administered by the USPS Cooperative Charting Committee.

USPS Cooperative Charting / Geodetic Program

An agreement first executed between USPS and NOAA in 1963

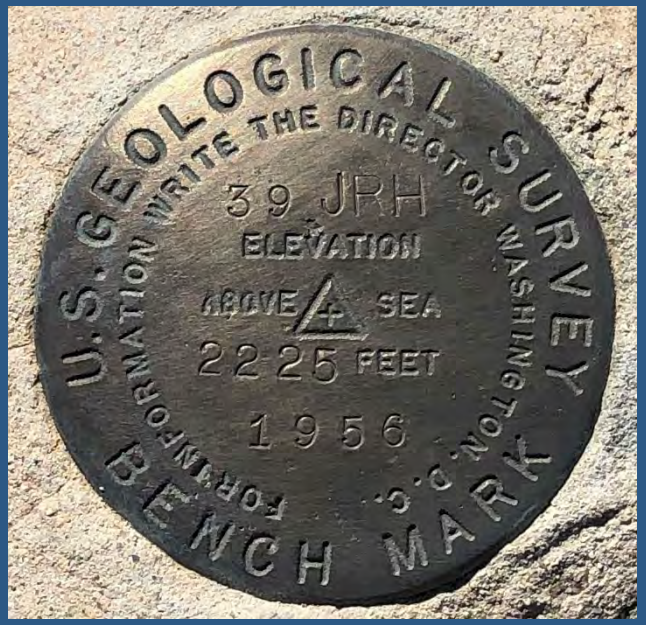
The USPS Geodetic Program is a separate program from Nautical and was/is not part of the former Cooperative Charting agreement with NOAA.

What are Geodetic Survey Markers?

Geodetic markers are highly accurate surveying reference points established on the surface of the earth by local, state, and national agencies – mainly by the National Geodetic Survey (NGS). NGS maintains a database of all markers meeting certain criteria.

Common Synonyms for "Survey Marker"

Note: the words
"Geodetic",
"Survey" or
"Geodetic Survey"
may precede each synonym.



- Mark
- Marker
- Marker Station
- Benchmark*
- Station
- Station Mark
- Control
- Control Point
- Control Station
- Cap
- Tablet
- Station Tablet
- Monument

* Bench Mark (two words) is a specific type of vertical survey mark.

What is a Marker Recovery?

Marker Recovery is the act of locating a geodetic marker in the field and reporting its condition along with any new or supplemental information on its location relative to surroundings.

Why is Marker Recovery Important?

Geodetic survey markers are placed on the earth's surface to establish "key permanent survey points". Preservation of the markers is of utmost importance to users (surveyors, map makers, builders, engineers, and other professionals). Users need to know which marks are still viable, missing, or need maintenance. Many valuable geodetic marks are destroyed by construction, new roads, erosion, or for other causes.

Damaged Marker
Out of Service

USPS Geodetic Recovery Reporting Steps

1) Geodetic Marker Recovered

2) Recovery Report Submitted to USPS Cooperative Charting Committee (CCC)

3) Report Reviewed by CCC for Approval and Credits

4) Coop Com Submits Report Data & Photos to NGS

5) NGS Updates Database

The National Geodetic Survey - Historical

Earliest roots of the Survey:

The "Survey of the Coast", our Nation's first civilian scientific agency, was established by President Thomas Jefferson in 1807.

Its mission was, to survey the U.S. coastline and create nautical charts of the coast to help increase maritime safety.

Ref. 1

The National Geodetic Survey - Historical

Formation of the Geodetic Survey:

As the nation grew westward surveys of the U.S. interior began.

In 1878 the agency was given a new name, the "U.S. Coast and Geodetic Survey", which it maintained until 1970 when it became the "National Geodetic Survey" within the National Ocean Service of NOAA.

Ref. 1

NGS Naming History

1807 - Survey of the Coast

1836 - Coast Survey

1878 - US Coast and Geodetic Survey (USC&GS)

1899 - Coast and Geodetic Survey

1979 - National Ocean Survey (*later* "Service")

1970 - National Geodetic Survey (NGS) *

Refs: 1 & 29

** A functional unit within NOAA's National Ocean Service*

U.S. Department of Commerce
USDOC

National Oceanic and Atmospheric Administration
NOAA

NOAA is one of 12 “Bureaus” in the USDOC

National Ocean Service
NOS

NOS is one of 6 “Line Offices” in NOAA

National Geodetic Survey

NGS

NGS is one of 8 “Program Offices” in the National Ocean Service

Role of National Geodetic Survey

NGS has the responsibility for the definition and maintenance of the national horizontal and vertical datums used by the various other agencies to define national mapping (USGS), coastal charting (NOAA/Office of Coast Survey), and Aeronautical Charting (FAA), as well has a host of other applications.

Although many different agencies including NGS have installed marks, only NGS maintains a nation-wide digital database where marks from any source can be registered if they meet certain criteria.

What is a Datum?

A Datum is a reference from which measurements are made. Datums are typically used for relative quantities, such as horizontal or vertical position.

A Datum for horizontal position is referenced from a physical point from which all other stations are measured by angles and distances. Units commonly used for mapping are latitude and longitude.

A Datum for elevation consists of heights above or below either a physical point or a mean position determined by tide gauges (called sea level elevation). In both cases, the benchmarks are relative to a geoid model as the survey extends farther and farther from the actual datum point.

US Geodetic Datums

NAD 27 (North American Datum of 1927) – Horizonal Datum for Continental U.S. - developed using a mathematical adjustment from the datum point located on Meades Ranch, Kansas - Common on older USGS maps and Nautical charts

NAD 83 (North American Datum of 1983) – Horizontal Datum for Continental U.S. – it's datum point is the center of the earth as determined by 30 years of satellite orbits - common on maps and charts after 1983.

WGS 84 (World Geodetic System of 1984) – Horizontal Datum identical to NAD 83 in US but gradually veering from the coordinate determination as distances extend beyond the continent. Used by military overseas and is the default datum used by the GPS system.

NGVD 29 (National Geodetic Vertical Datum of 1929) - for the Continental U.S. – reference was mean tide average for 26 tidal stations in US & Canada

NAVD 88 (North American Vertical Datum of 1988) - Used on most newer USGS maps – reference is based on one mean tide tidal station in Quebec – considered more accurate as adjustment done by computers

Types of Geodetic Survey Marks

Primary Survey Marks are mainly of two basic types:

Horizontal Control

Vertical Control

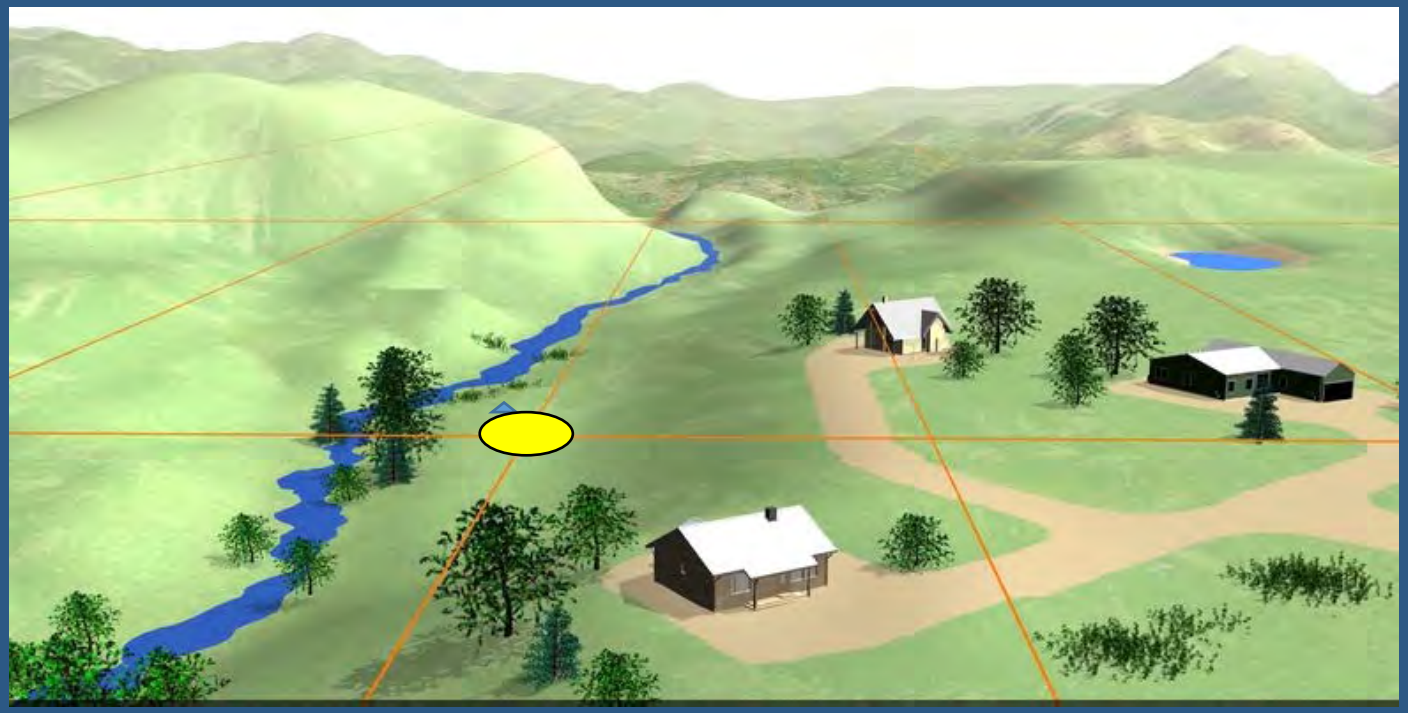
Some Marks are both horizontal and vertical.

Although the advances in GPS technology have made the horizontal reference marks less of a necessity in surveying, GPS cannot measure elevations accuracy, so the vertical reference marks are still necessary for accurate surveying.

Ref. 6

Horizontal Control Marks

- Used for distances and directions across surface of earth
- Latitude / Longitude coordinates define position
- Current NA Horizontal Datum is NAHD 83 (1983)
- The central US reference mark is on Mead's Ranch in KS



Ref. 6 (modified)

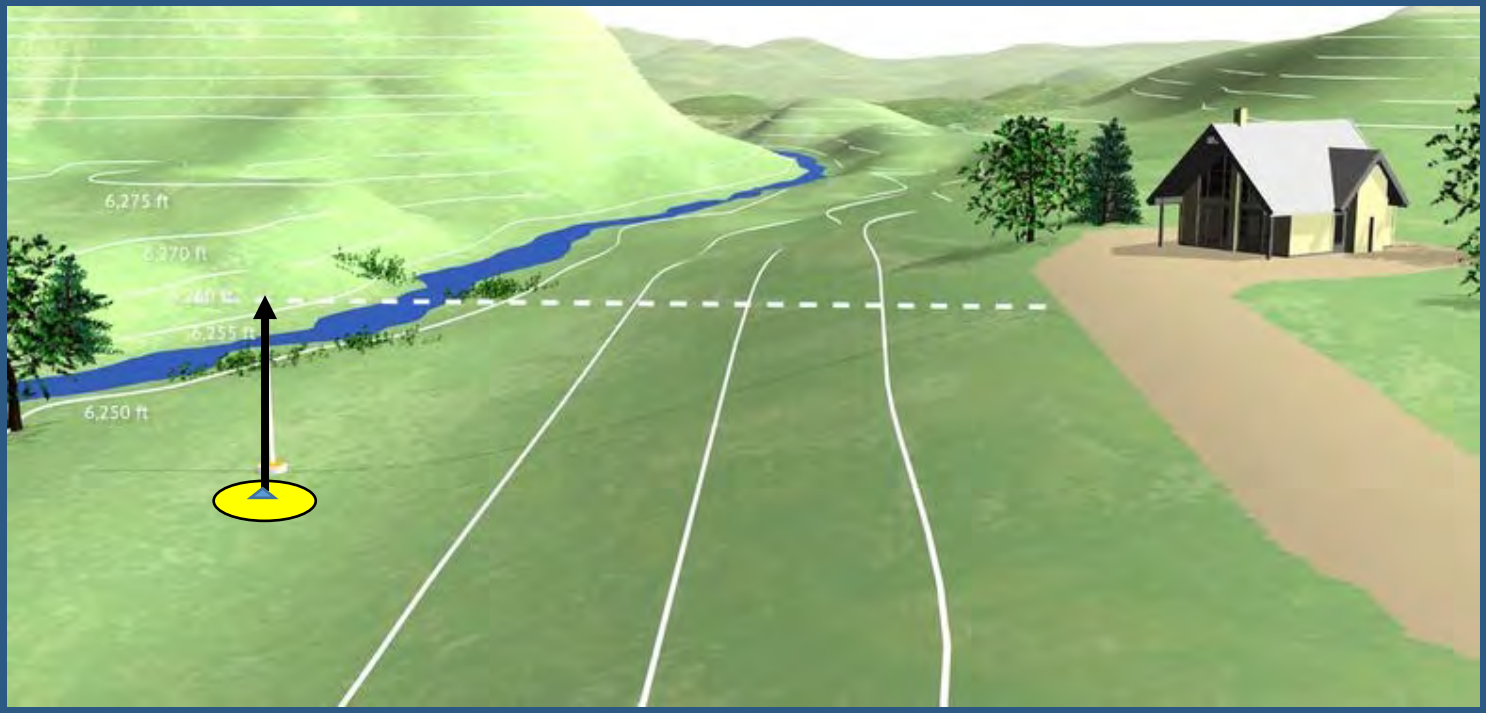
US Horizontal Datum Point

In 1901, the Meades Ranch station was chosen as the United States standard horizontal datum: the point relative to which all land measurements in the nation were made.

KG0640 (MEADS RANCH 1891 Reset)
39 13’ 26.71” N 098 32’ 31.75” W

Vertical Control Marks

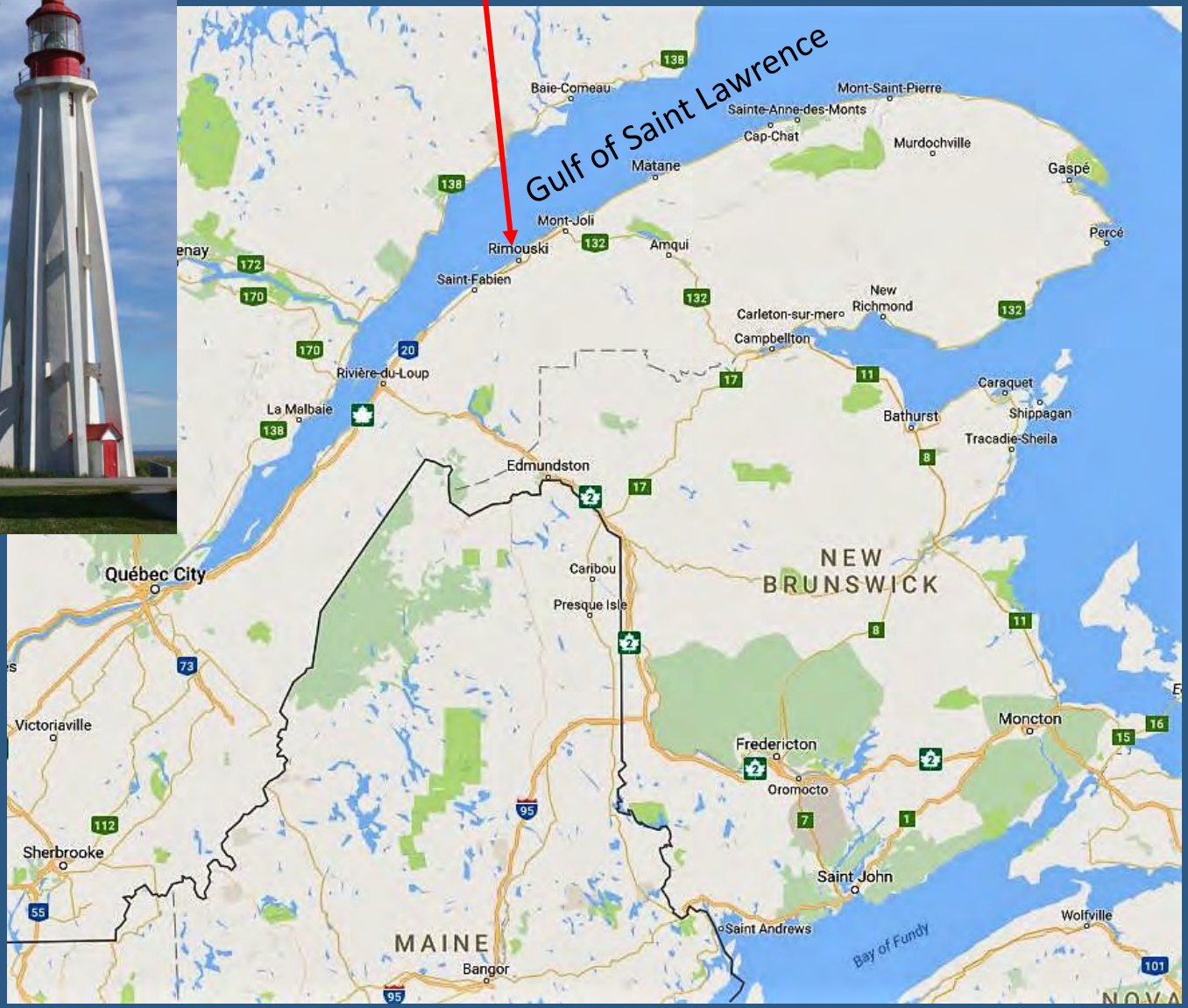
- Used for elevations, water depths, flood plains
- Current NA Vertical Datum is NAVD 88 (1988)
- The “0” elevation reference point is the mean tide at Father Point tidal station at Rimouski, Quebec CAN



Ref. 6 (modified)

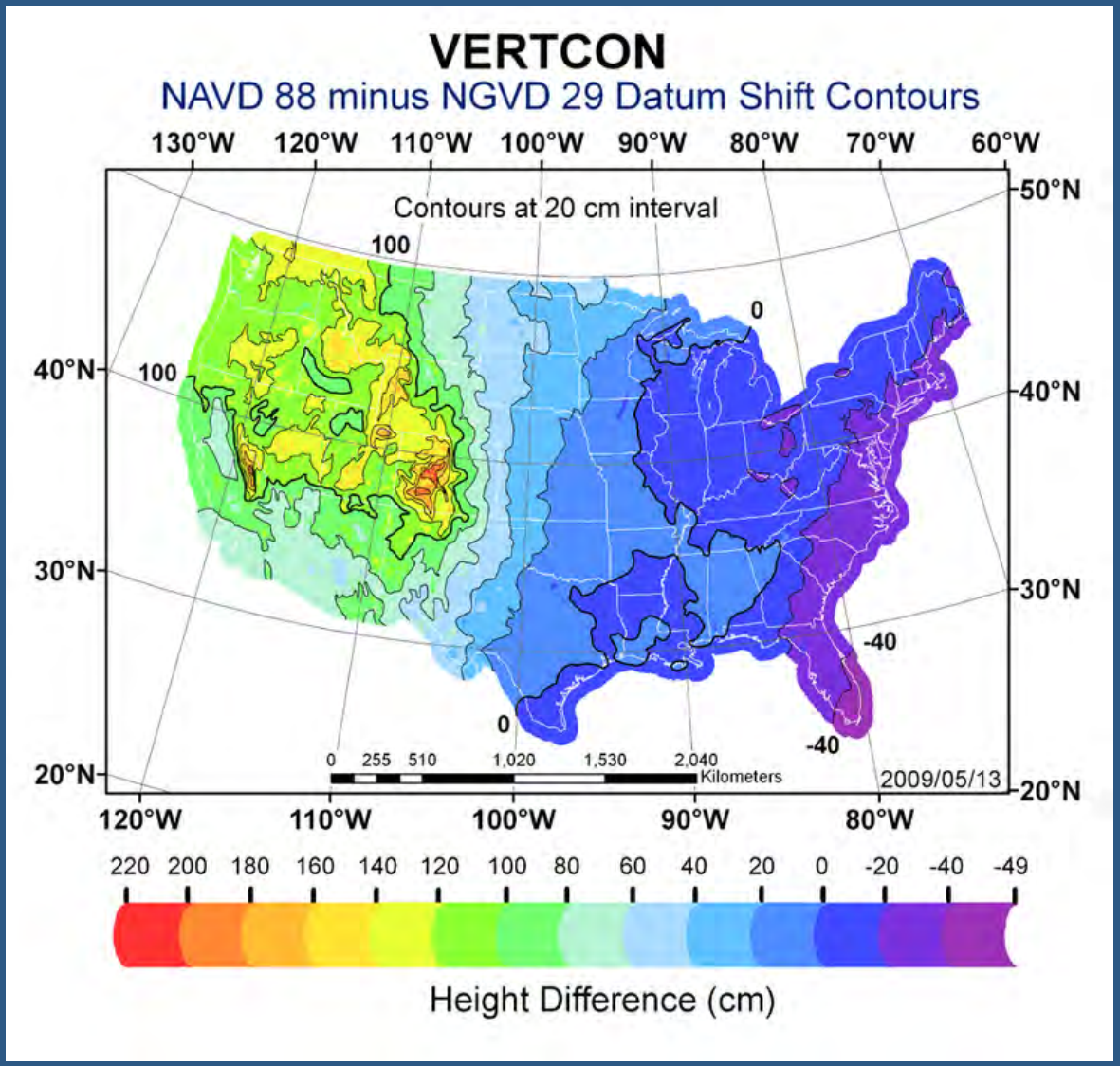
Rimouski, Quebec, CAN

Ref. 7



Comparison of Older and Newer NA Vertical Datums

VERTCON is a program that computes the modeled difference in orthometric height between the older NGVD 29 and the newer NAVD 88 Vertical Datums



http://www.ngs.noaa.gov/TOOLS/Vertcon/Vertcon_Map.html

Placement of Survey Markers

"How did they get get there?"

Surveying (now geomatics) has traditionally been defined as the science, art, and technology of determining the relative positions of points above, on, or beneath the earth's surface, or of establishing such points .

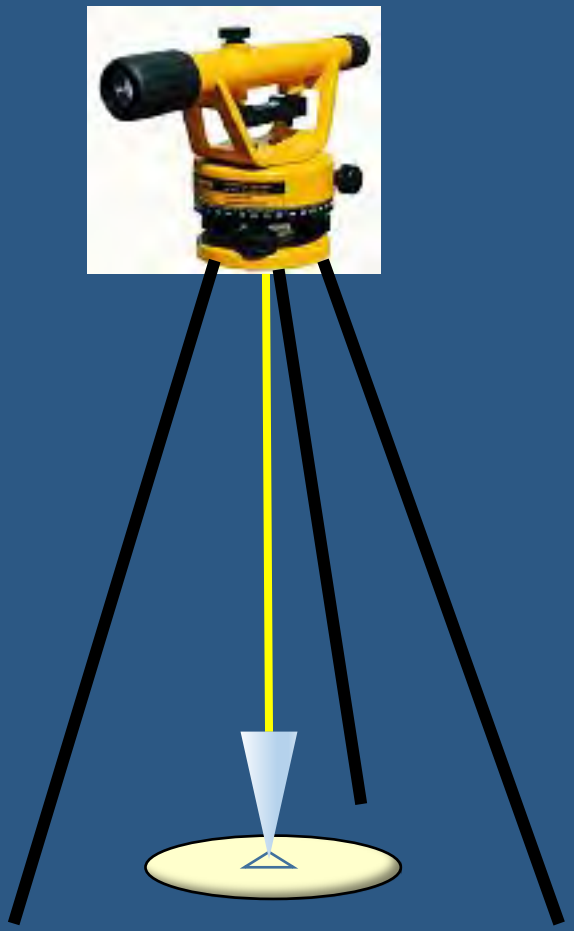
Ref 17

The Marks were placed by Survey Crews!

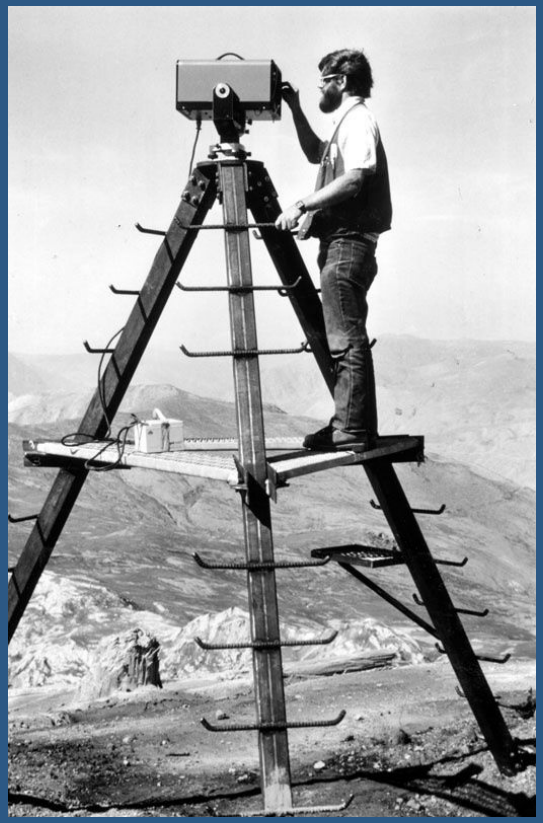
Because they used different surveying methods, the crews that did Vertical Marks were usually different than the crews did Horizontal Marks!

Ref. 6

For Surveying – Plumb bob is placed over center point of Mark



“Surveying Methods” for Placing Marks



Ref. 3

Vertical Methods

Horizontal Methods

“Vertical” Surveying Methods

- Spirit Leveling
- Trigonometric Leveling
- Barometric Leveling

For placing Elevation Marks !

Vertical Methods – Spirit Leveling Example

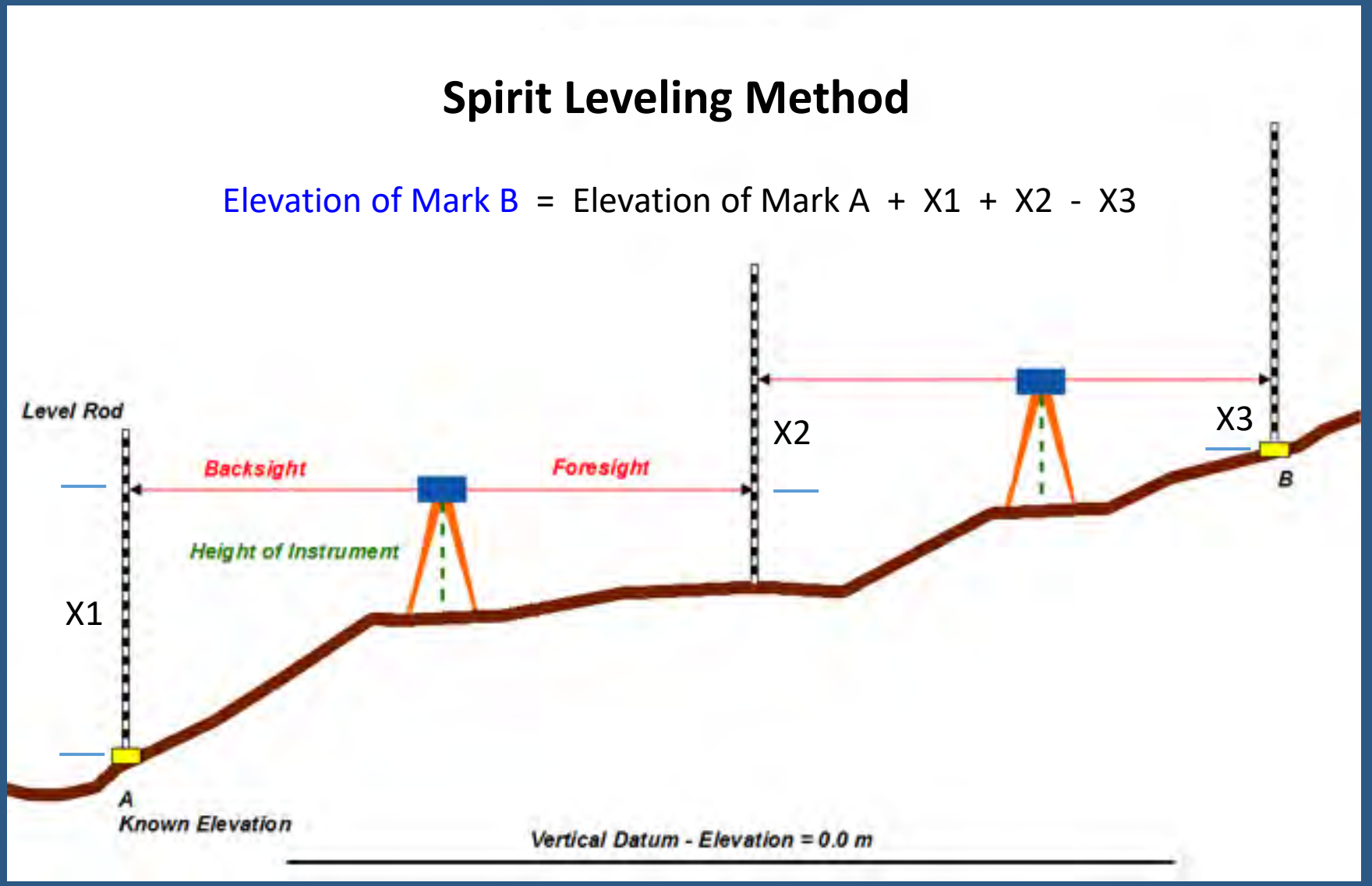
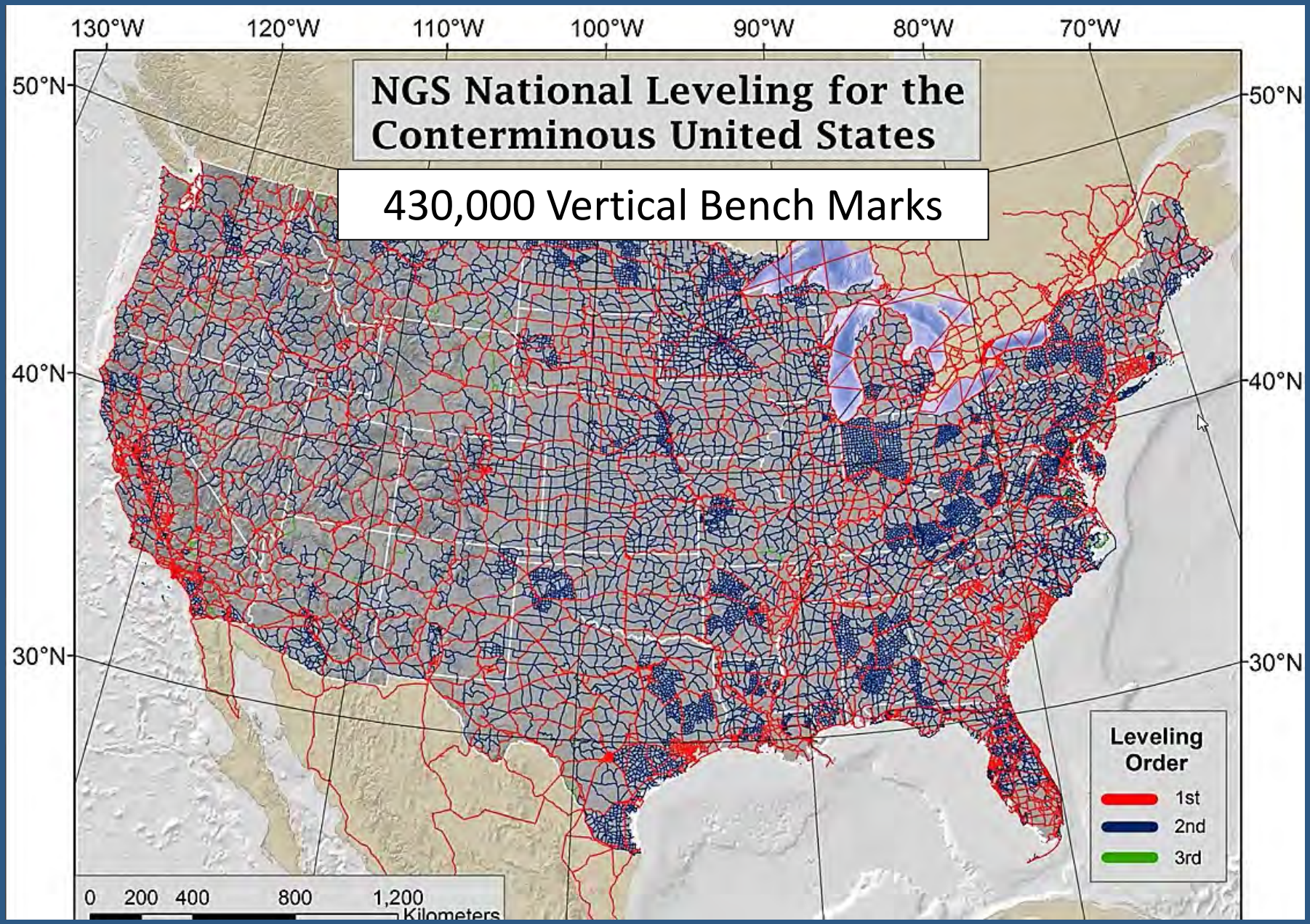


Diagram picture from NGS modified



Ref. 6 (modified)

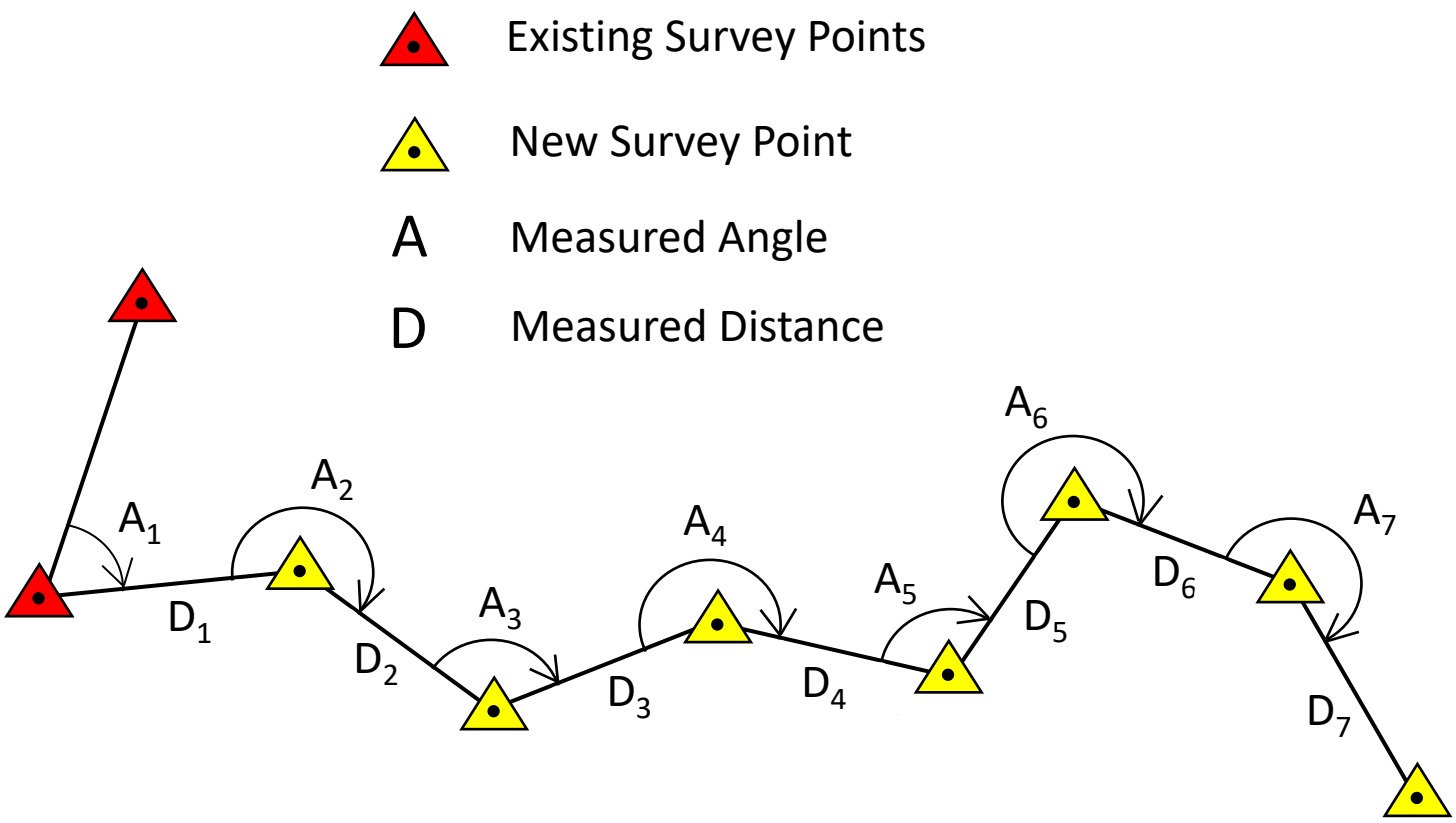
“Horizontal” Surveying Methods

- Triangulation
- Traverse
- Trilateration

For placing Lat / Lon Marks

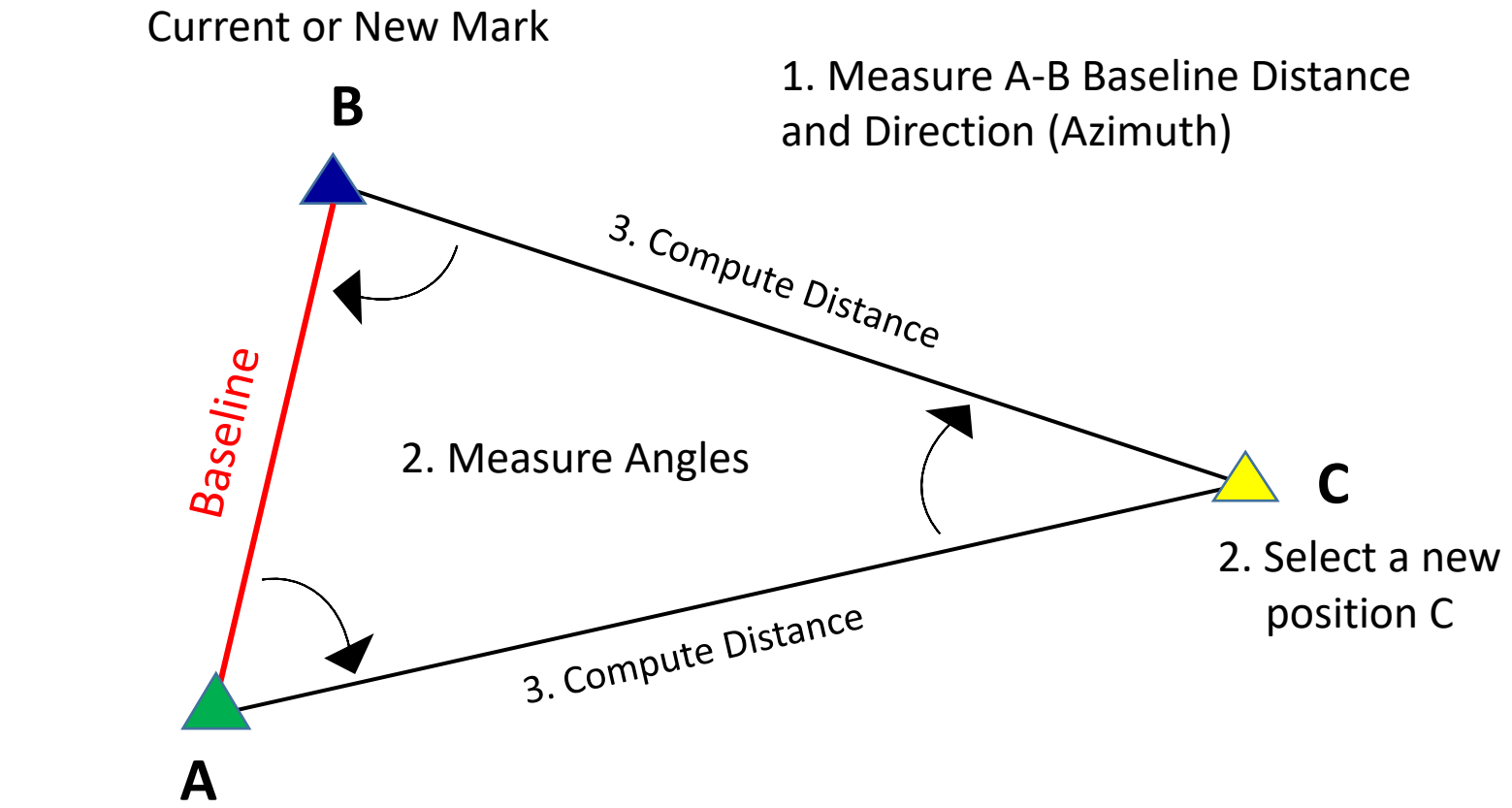
Horizontal Methods – Traverse Example

Traverse Survey Method



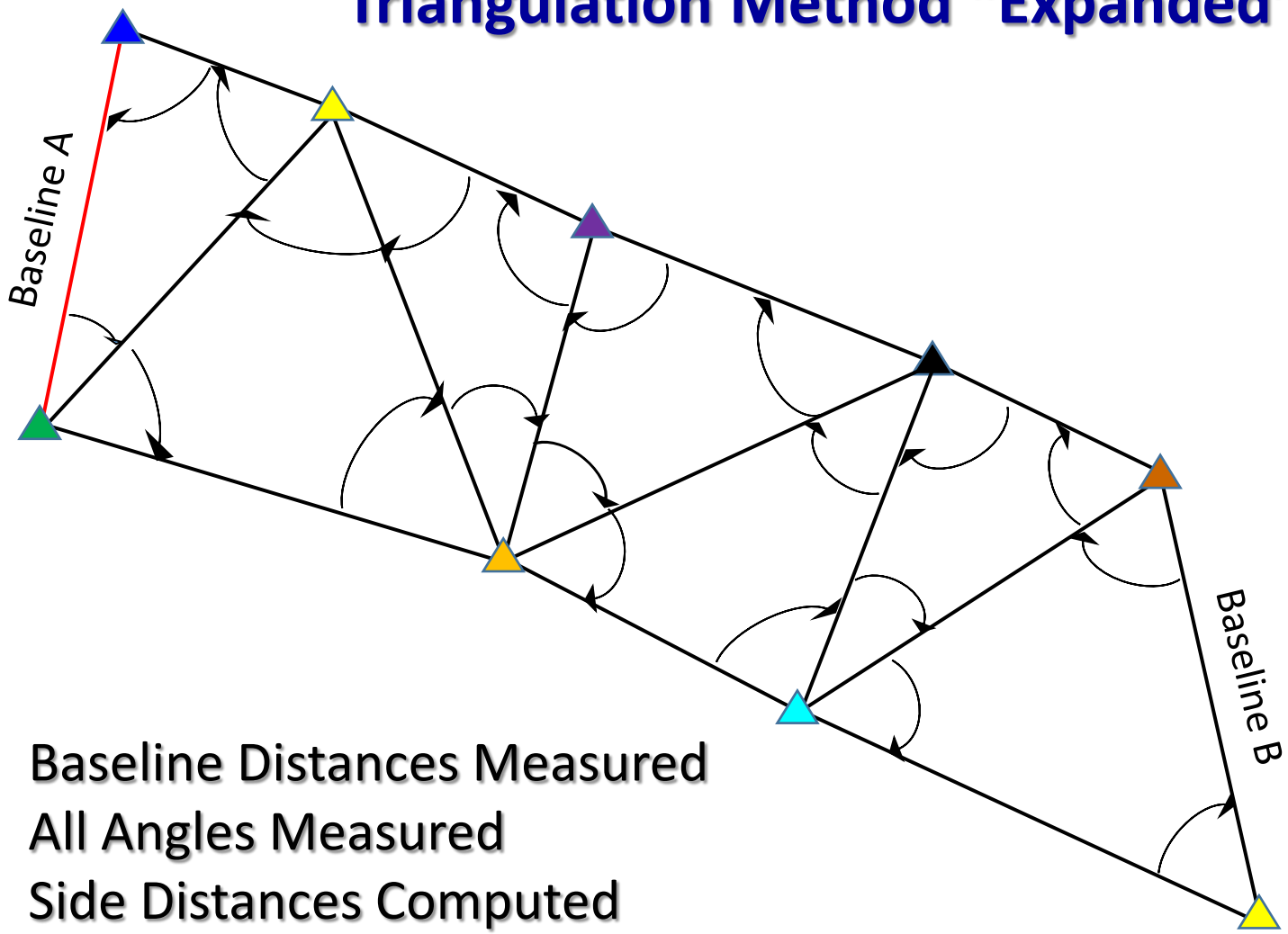
Horizontal Methods – Triangulation Example

Triangulation Method



Inspired by Ref. 6

Triangulation Method “Expanded”



- Baseline Distances Measured
- All Angles Measured
- Side Distances Computed

Inspired by Ref. 6

Early extended Horizontal Triangulation Survey in Eastern United States from Calais, ME to New Orleans, LA

Ref. 1

Status of Horizontal Triangulation Network 1931

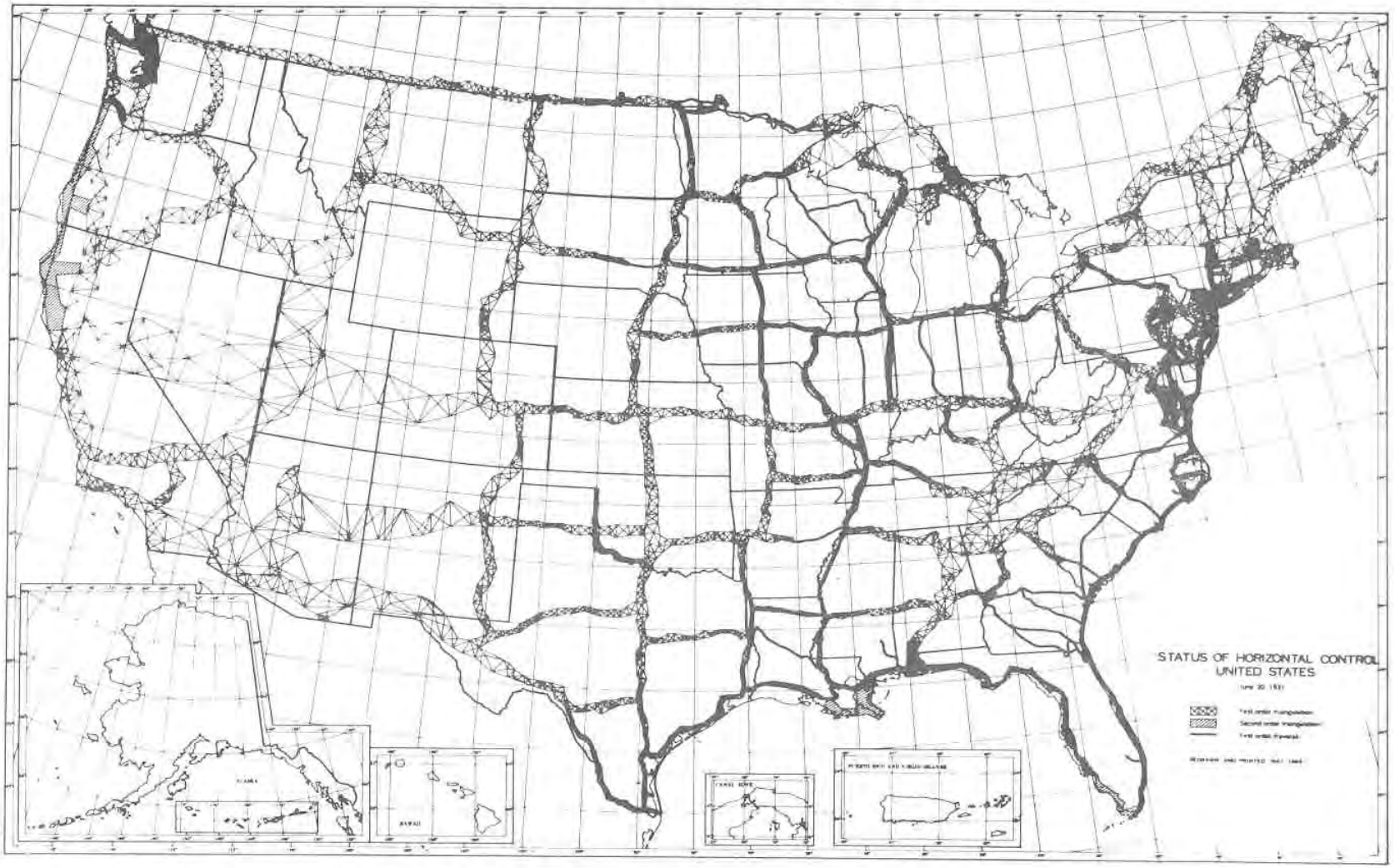


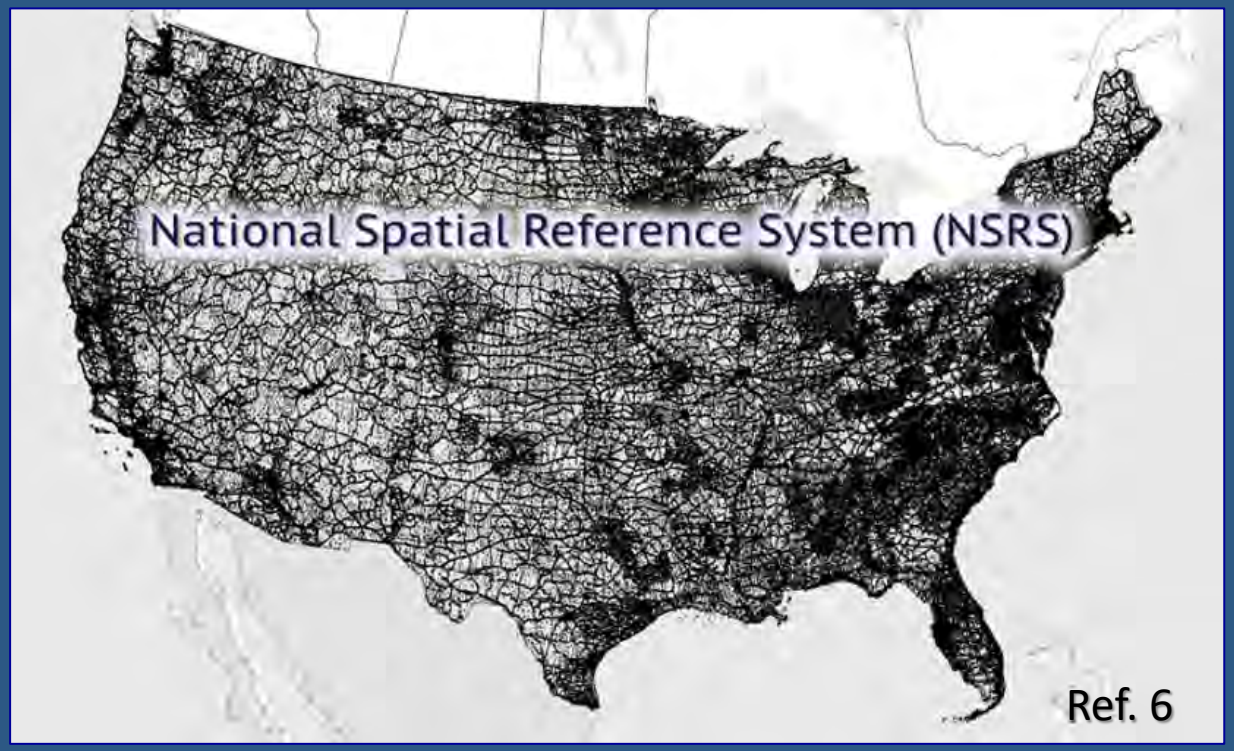
Figure 3

Horizontal Control Network of the United States June 1931

Ref. 1

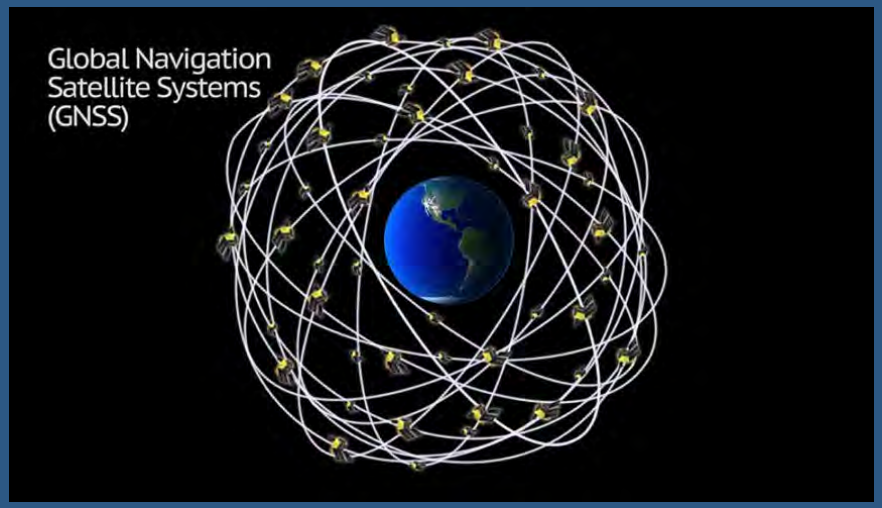
The National Spatial Reference System

The common set of reference point benchmarks from the horizontal and vertical datums in the United States make up what is known as the National Spatial Reference System (NSRS).



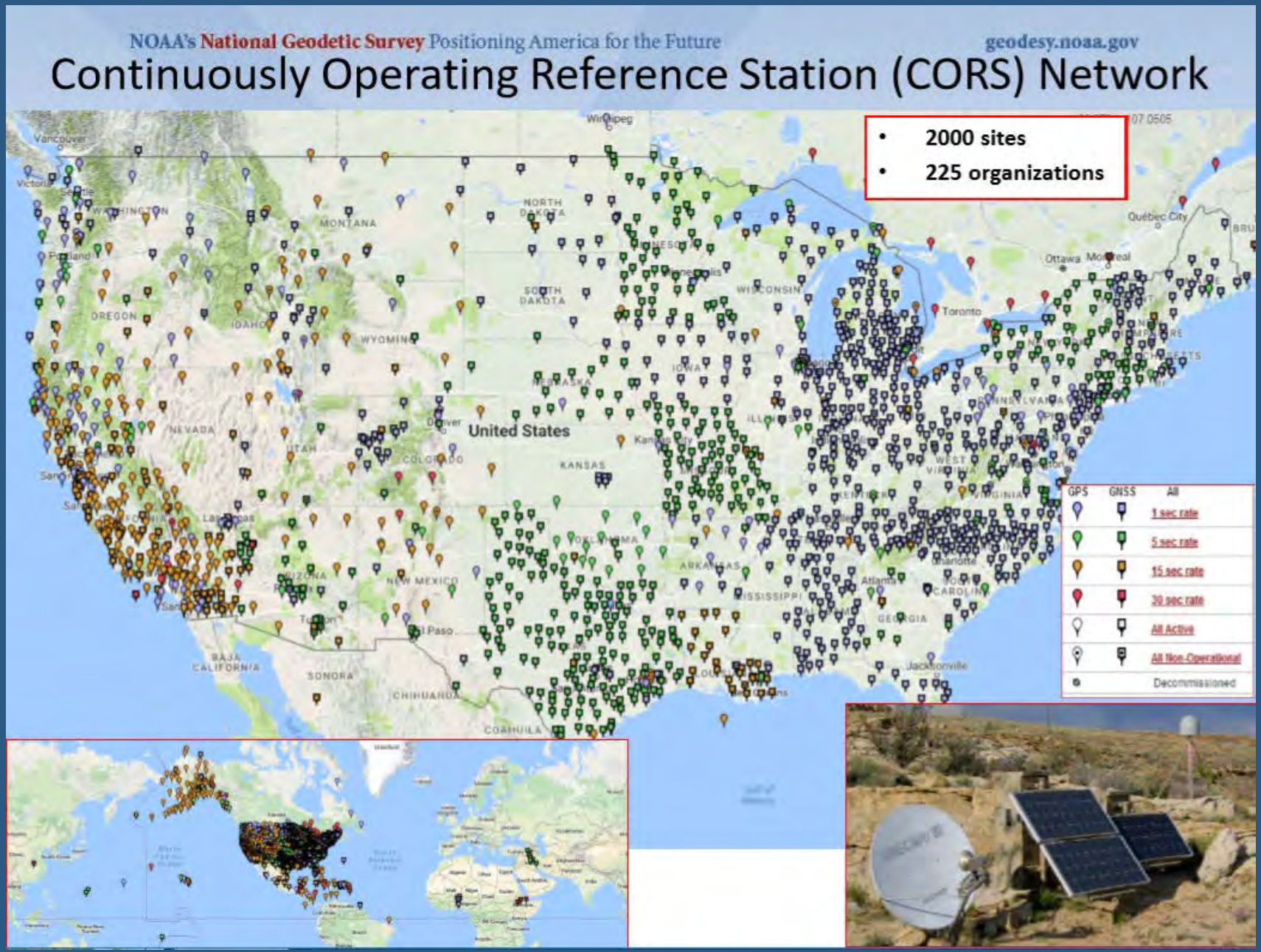
More than 1.5 Million points (marks & GPS sites) based on 200 years of historical data

Geodetic Modernization Program: GPS is used to improve location accuracy of marks



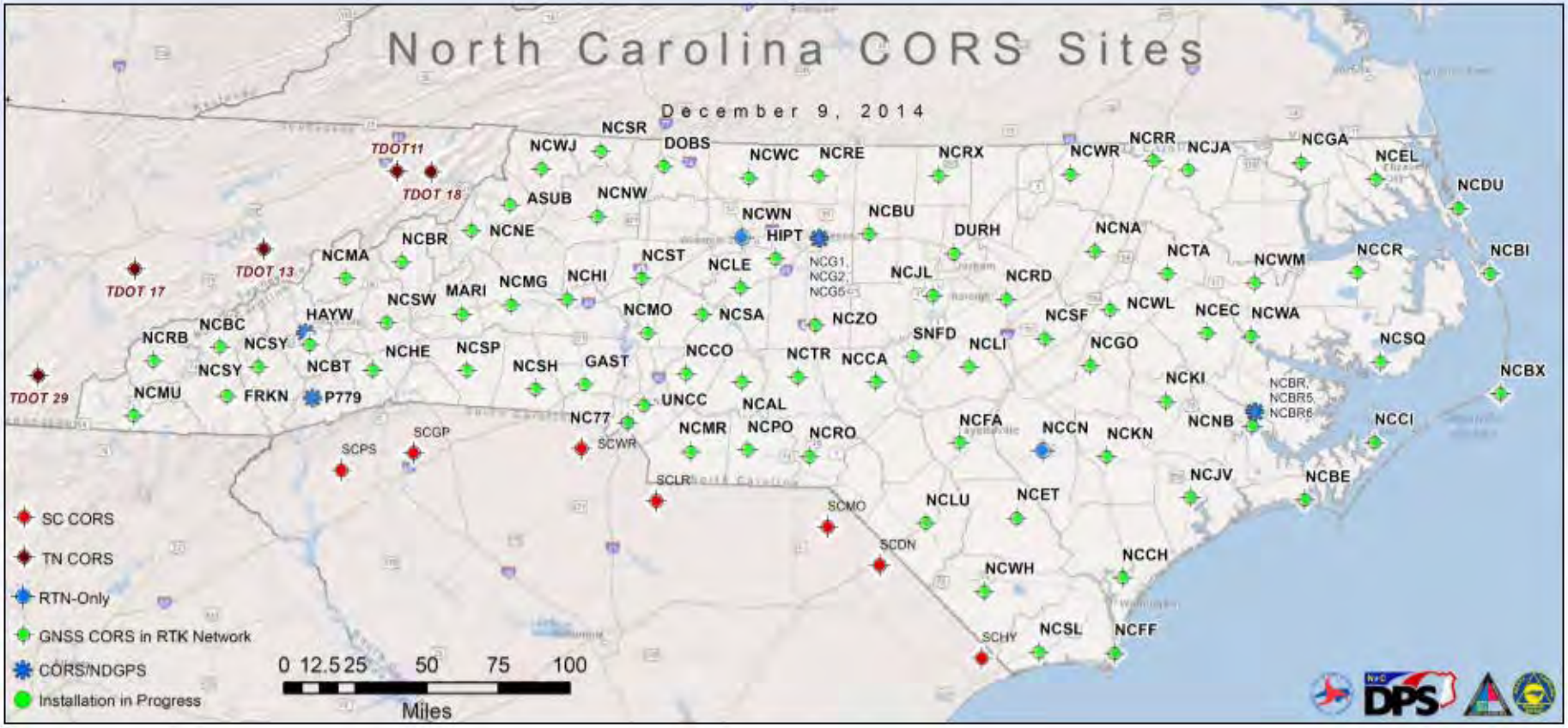
Mark GPS Augmentation

Pictures from NOAA Video Library


NOAA's National Geodetic Survey Positioning America for the Future
geodesy.noaa.gov
Continuously Operating Reference Station (CORS) Network
• 2000 sites
• 225 organizations
United States
GPS
GNSS
All
1 sec rate
5 sec rate
15 sec rate
30 sec rate
All Active
All Non-Operational
Decommissioned

Ref. 5

NC CORS Network (91 Stations)



NC Typical CORS Spacing 10 – 50 Miles

Ref. 7

A New Datum is on the Horizon

Horizontal Datum NAHD 83 and
Vertical Datum NAVD 88
will be replaced with a new datum
"North American-Pacific Geopotential Datum of 2022"
NAPGD2022
based primarily on Global Navigation Satellite Systems e.g. GPS

The Current/Future Importance of Geodetic Markers

- Marks will play a "critical role" in support of the development of the 2022 datum and in supporting users of the datum
- Marks will be used with CORS (GPS) as part of the 2022 datum
- Marks will continue to be used by surveyors for project control, but the way they get and use the coordinates and elevations will be different than now
- GPS can measure elevations but with less precision than leveling, so leveled survey marks (Vertical Marks) are still needed for surveying

Ref. 8

The Current/Future Importance of Geodetic Markers – Cont.

- Advances in GPS technology has changed the reliance on horizontal marks
- Marks will be used for gravity observations
- In NC, unless the closest published mark is greater than 2000 ft away, horizontal surveys require a tie to a horizontal mark, and vertical surveys require a tie to a vertical mark – or, the ties can be satisfied using an appropriate Global Navigation Satellite System (GNSS) technique or NOAA's Online Positioning User Service (OPUS) that provides free access to high-accuracy National Spatial Reference System (NSRS) coordinates.

Ref. 8