

History of the Development of Geodetic Datums in the United States



Virginia Association of Sureyors
Williamsburg
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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 shores 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 extent 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 respect to St. George's bank, and any other bank or shoal, and the soundings and currents beyond the distance aforesaid to the gulph streams, as in his opinion may be especially, and convenient 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, in sum not exceeding fifty thousand dollars, to be paid out of any moneys in the treasury, not otherwise appropriated.

Mathematical Speaker of the House of Representatives

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

February 10, 1807

Approved

Jefferson

Testify that this act did originate
in the House of Representatives.

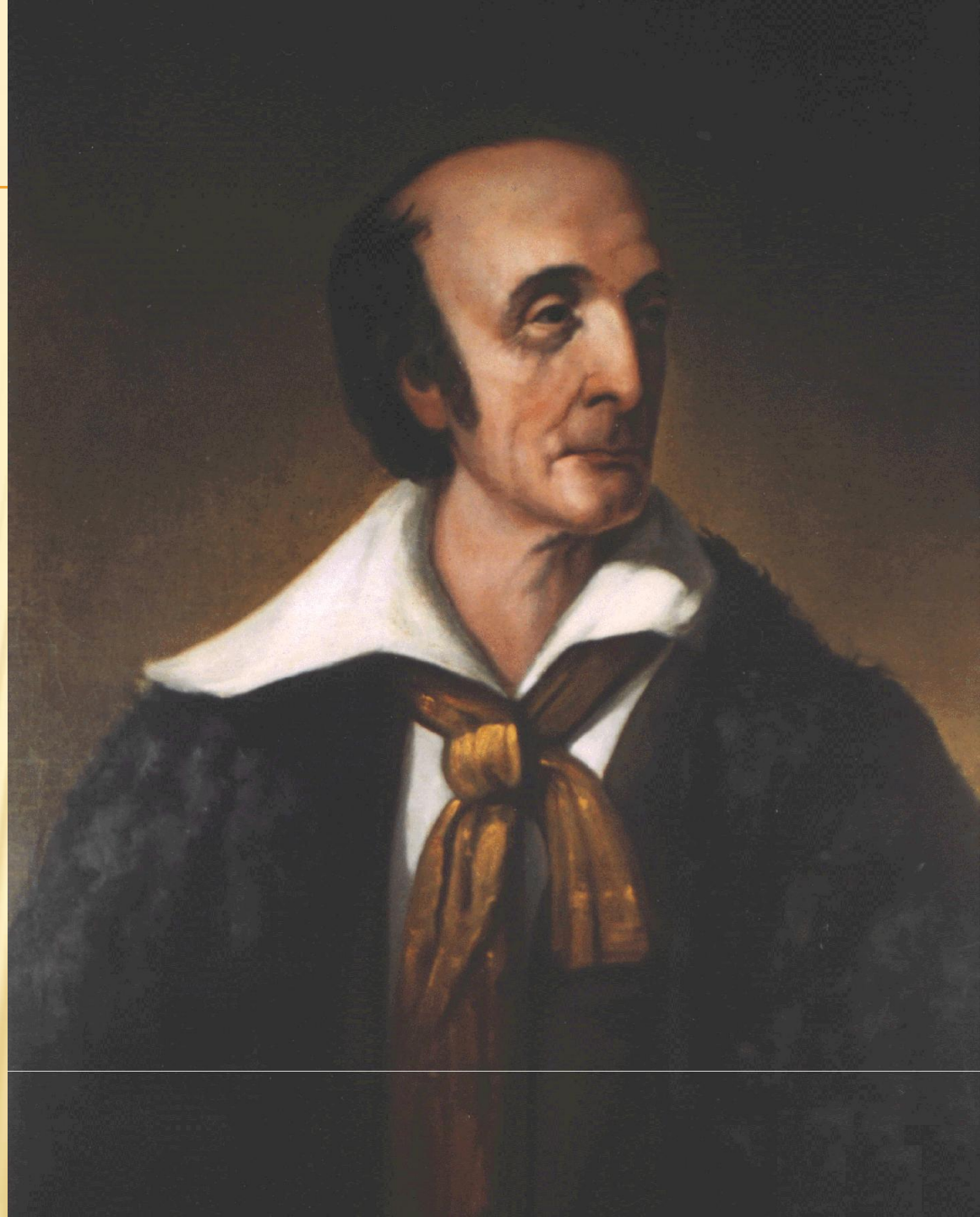
John Bradley Clark

FEBRUARY 10, 1807
PRESIDENT THOMAS JEFFERSON SIGNS LEGISLATION
ESTABLISHING THE SURVEY OF THE COAST

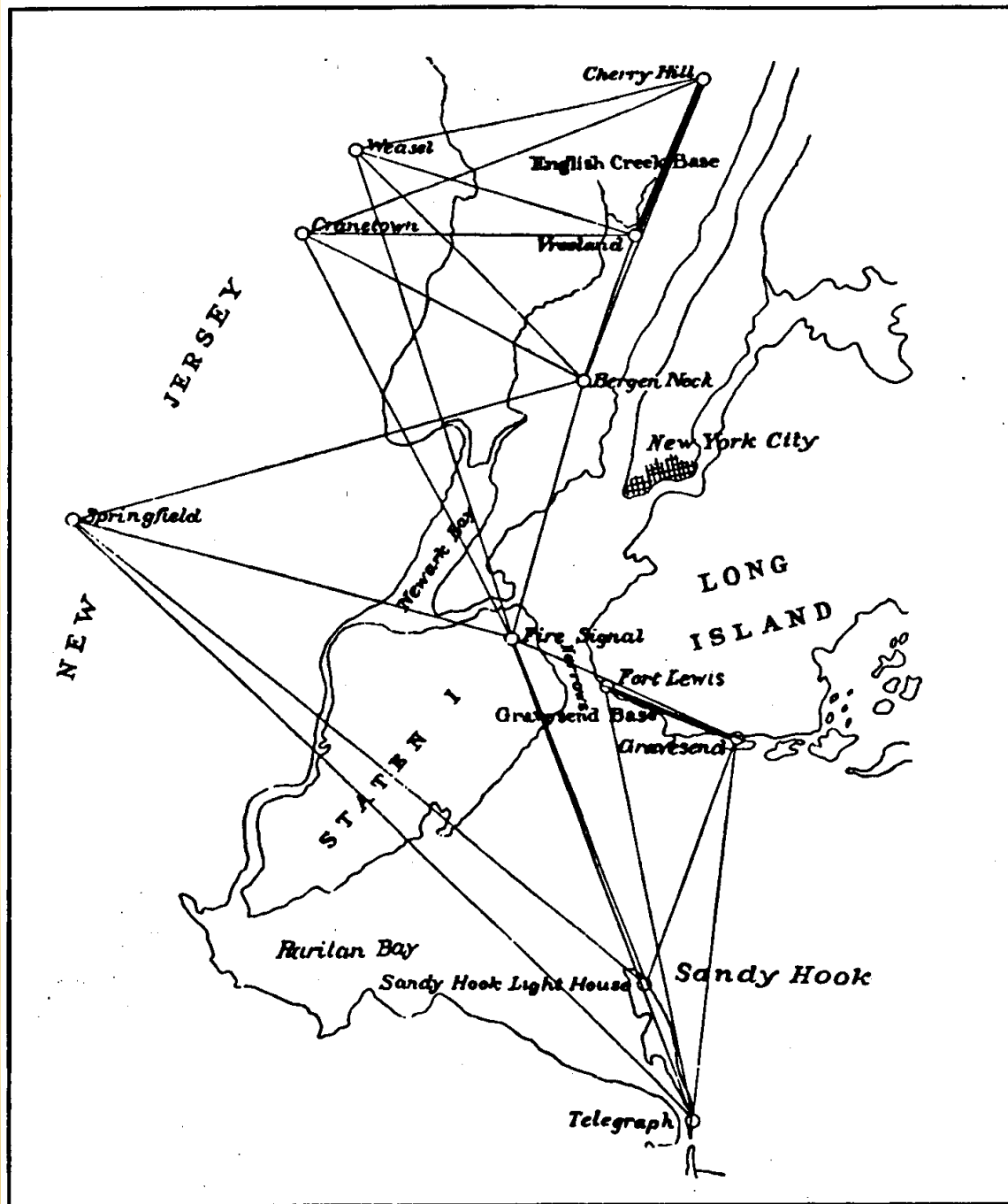
FERDINAND R. HASSLER
FIRST SUPERINTENDENT,
SURVEY OF THE COAST

Born: Oct. 7, 1770 Aarau
Switzerland

Died: Nov 20, 1843 near
Philadelphia, PA

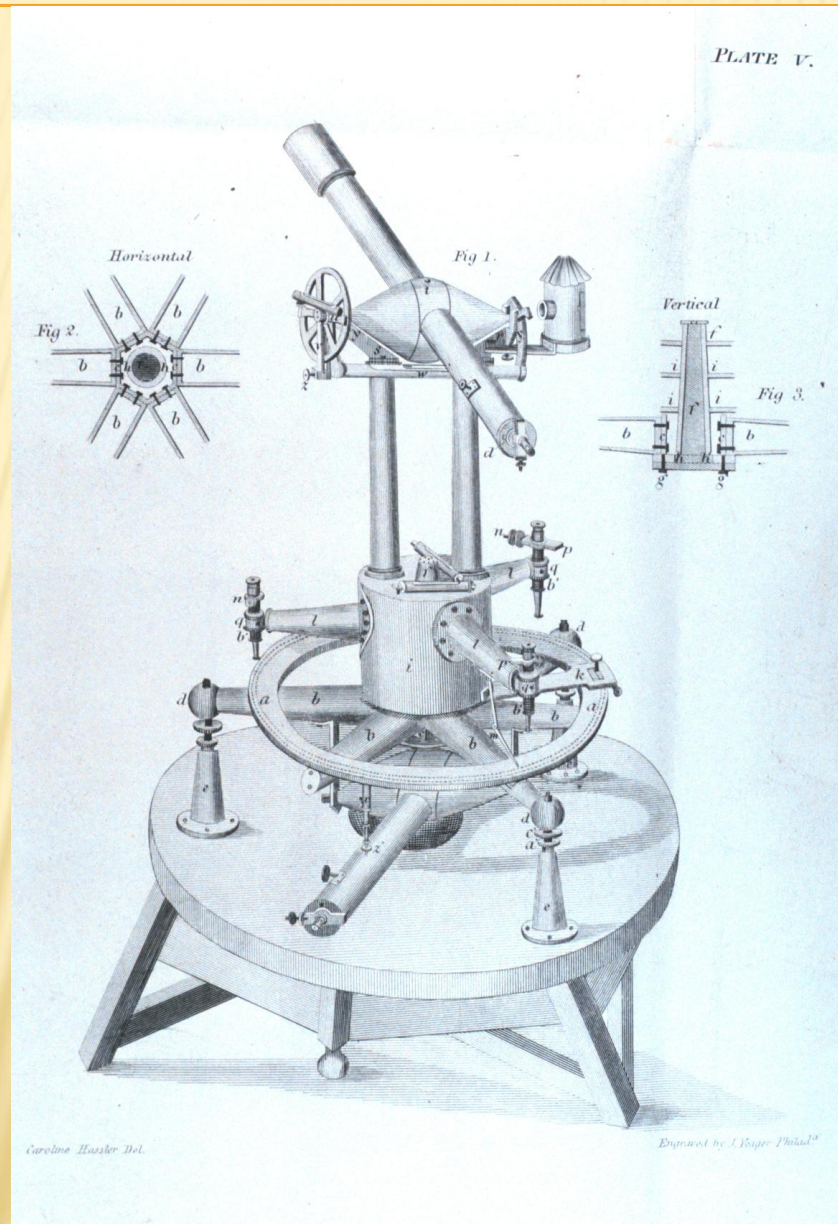


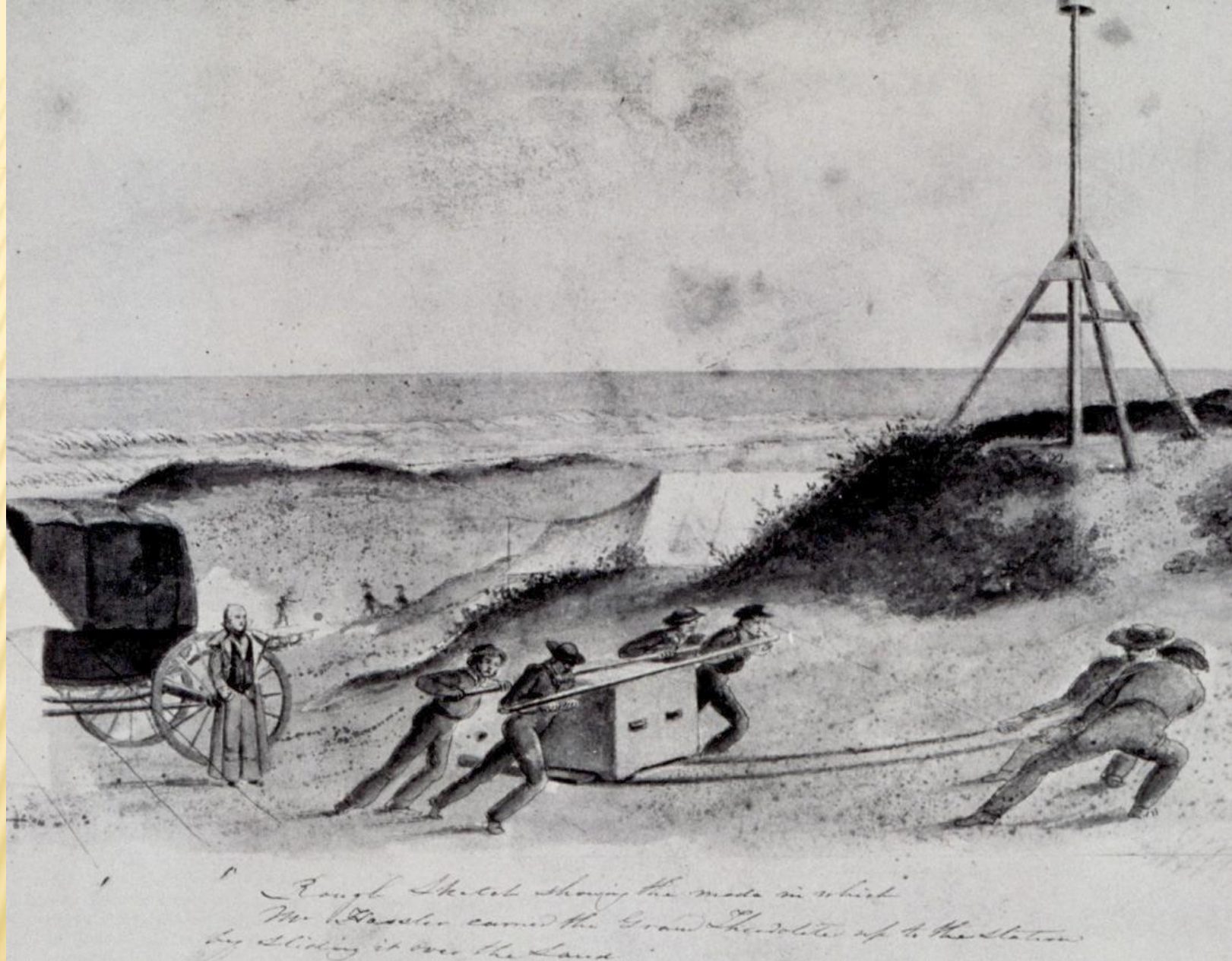
First Field
Work of the
“Survey of The
Coast”
1816-1817



Hassler's first field work, 1816-17.

24 Inch Troughton & Sims Theodolite drawn by Caroline Hassler





**Hassler Directs the Movement of the Great Theodolite on Fire
Island, NY - 1837**

24 Inch Theodolite in Hassler's Camp



DELAY 1817 - 1832

- NO PROGRESS DUE TO CONGRESSIONAL ACTION

RESTART 1832

- 1832 RECONNAISSANCE
- 1833 NEW YORK SURVEY RESUMED
- FIRST STATION OCCUPIED WAS BUTTERMILK 1833

ABOUT 800 METERS EAST OF THIS LOCATION LIES
THE OLDEST TRIANGULATION STATION
IN AMERICA


BUTTERMILK 1833
BUTTERMILK HILL

THIS PLAQUE IS ESTABLISHED
AS A BICENTENNIAL COMMEMORATION
THROUGH THE COOPERATION OF:

THE ROCKEFELLER FAMILY

THE NATIONAL GEODETIC SURVEY OF
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
AMERICAN CONGRESS ON SURVEYING AND MAPPING
THE WESTCHESTER-PUTNAM ASSOCIATION OF
PROFESSIONAL LAND SURVEYORS INCORPORATED

1976



**BUTTERMILK 1833
(LX4113)**

National Spatial Reference System (NSRS)

Consistent National Coordinate System

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

and how these values change with time



National Spatial Reference System

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

National Geodetic 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

NSRS Passive Control



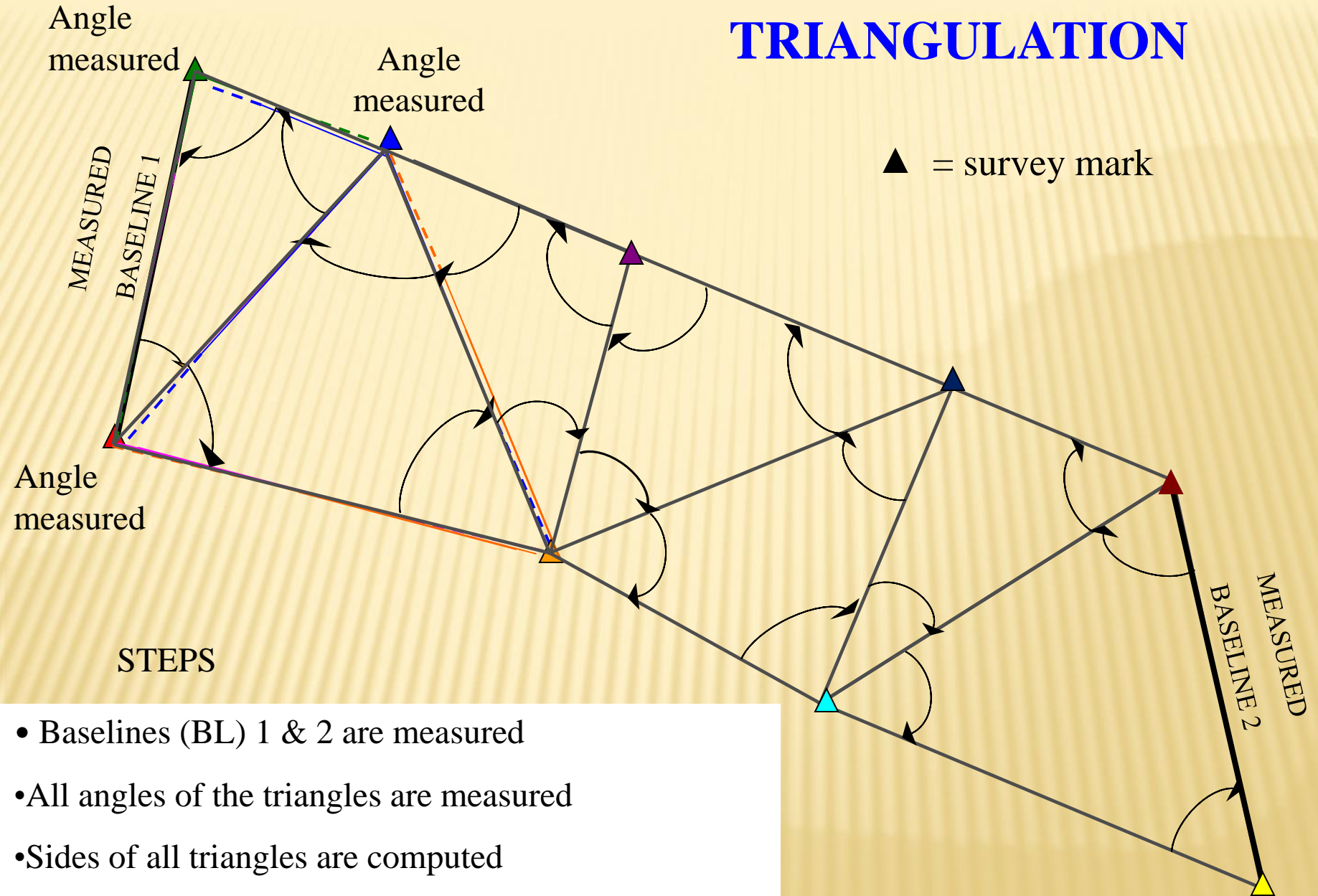
NSRS Active Control



Looking Northwest at BILL, 14OCT97



TRIANGULATION



▲ = survey mark

STEPS

- Baselines (BL) 1 & 2 are measured
- All angles of the triangles are measured
- Sides of all triangles are computed
- Computed length BL2 is compared to measured length of BL2

Triangulation Schemes

https://www.ngs.noaa.gov/data/survey_maps/gcdmap/



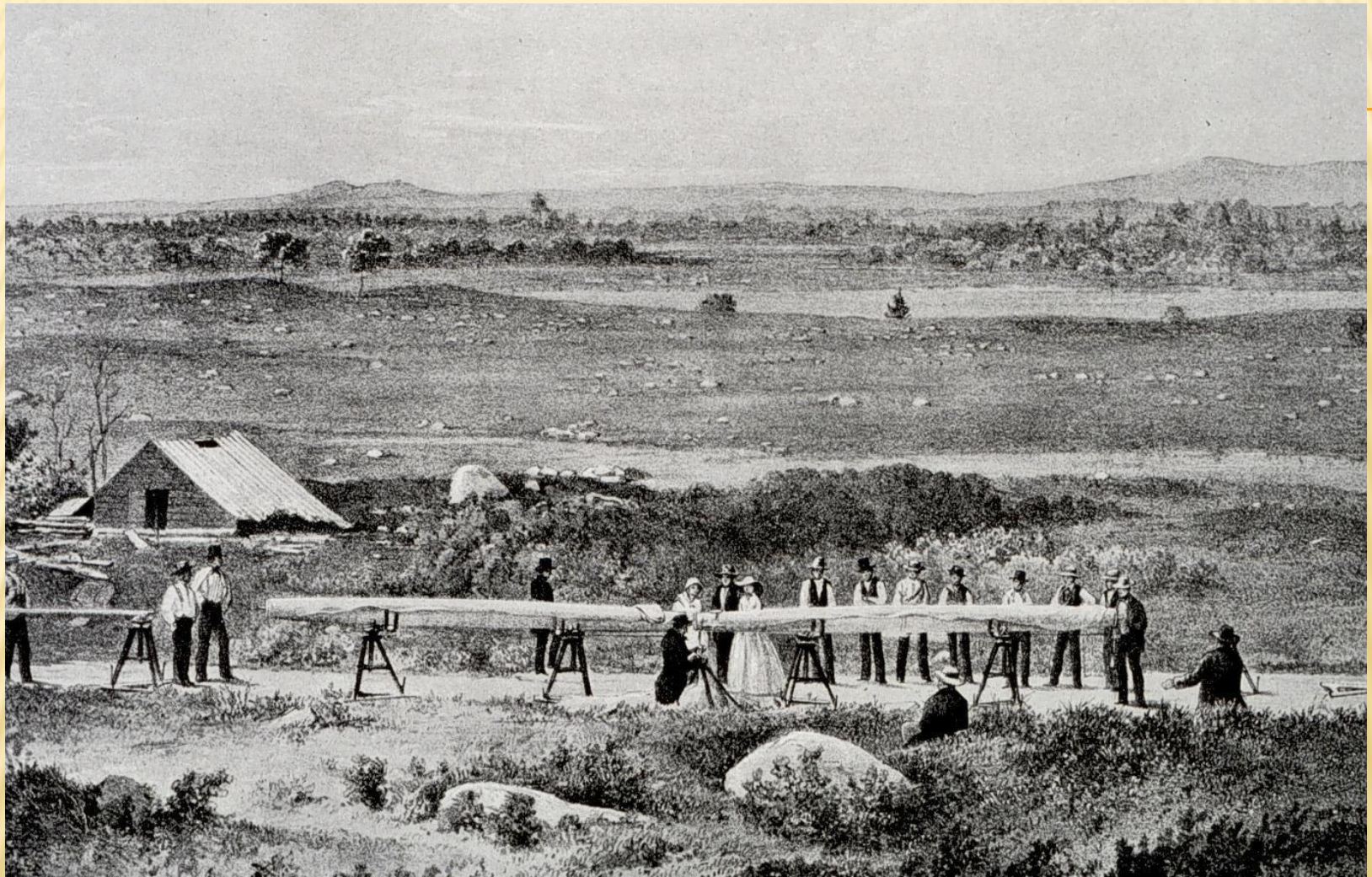
What's In a Name?

1807 - Survey of the Coast

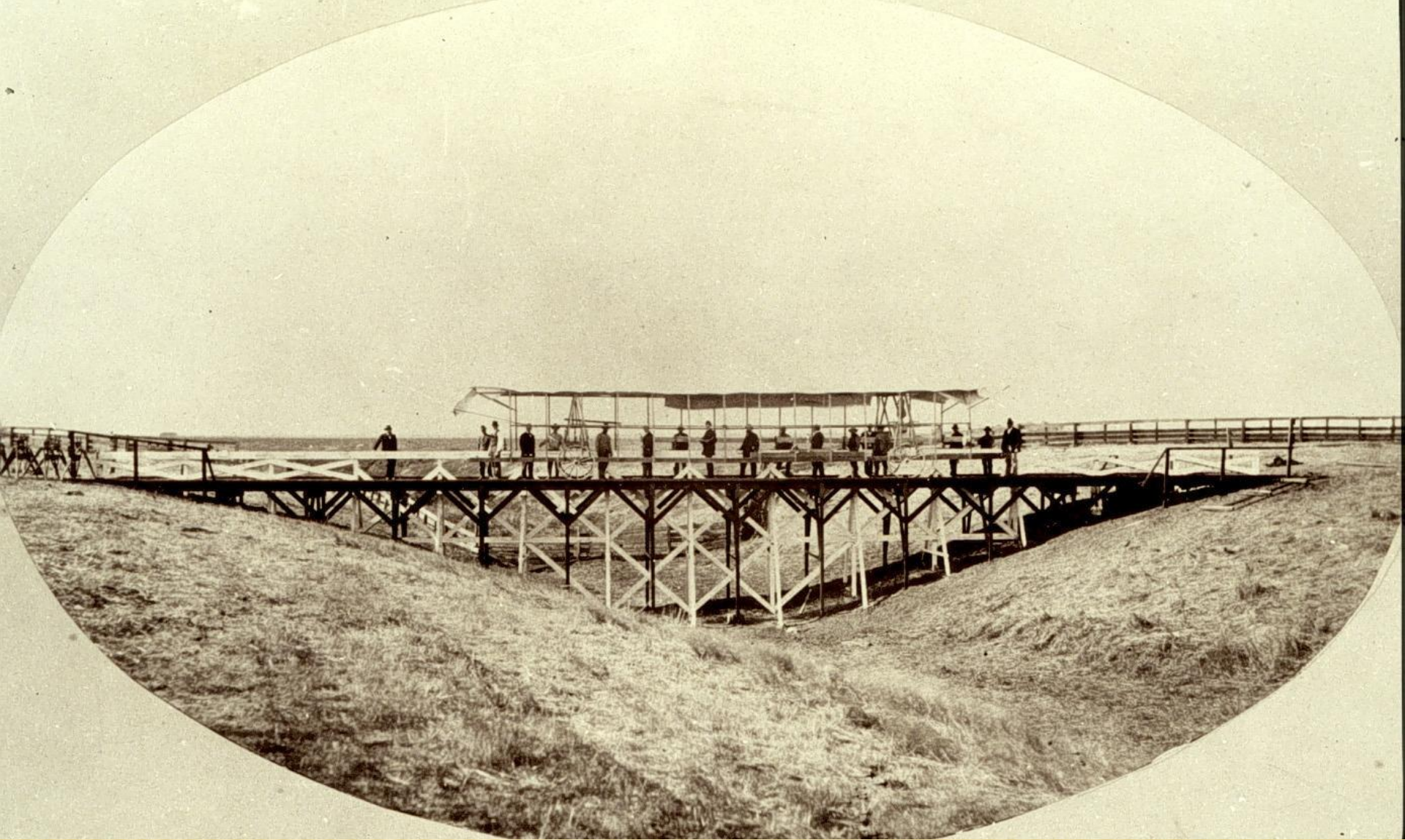
1836 - Coast Survey

1878 - US Coast and Geodetic Survey

**1970 - National Ocean Service
National Geodetic Survey**



Coast Survey Measuring the Epping Plains Base (Maine) 1859

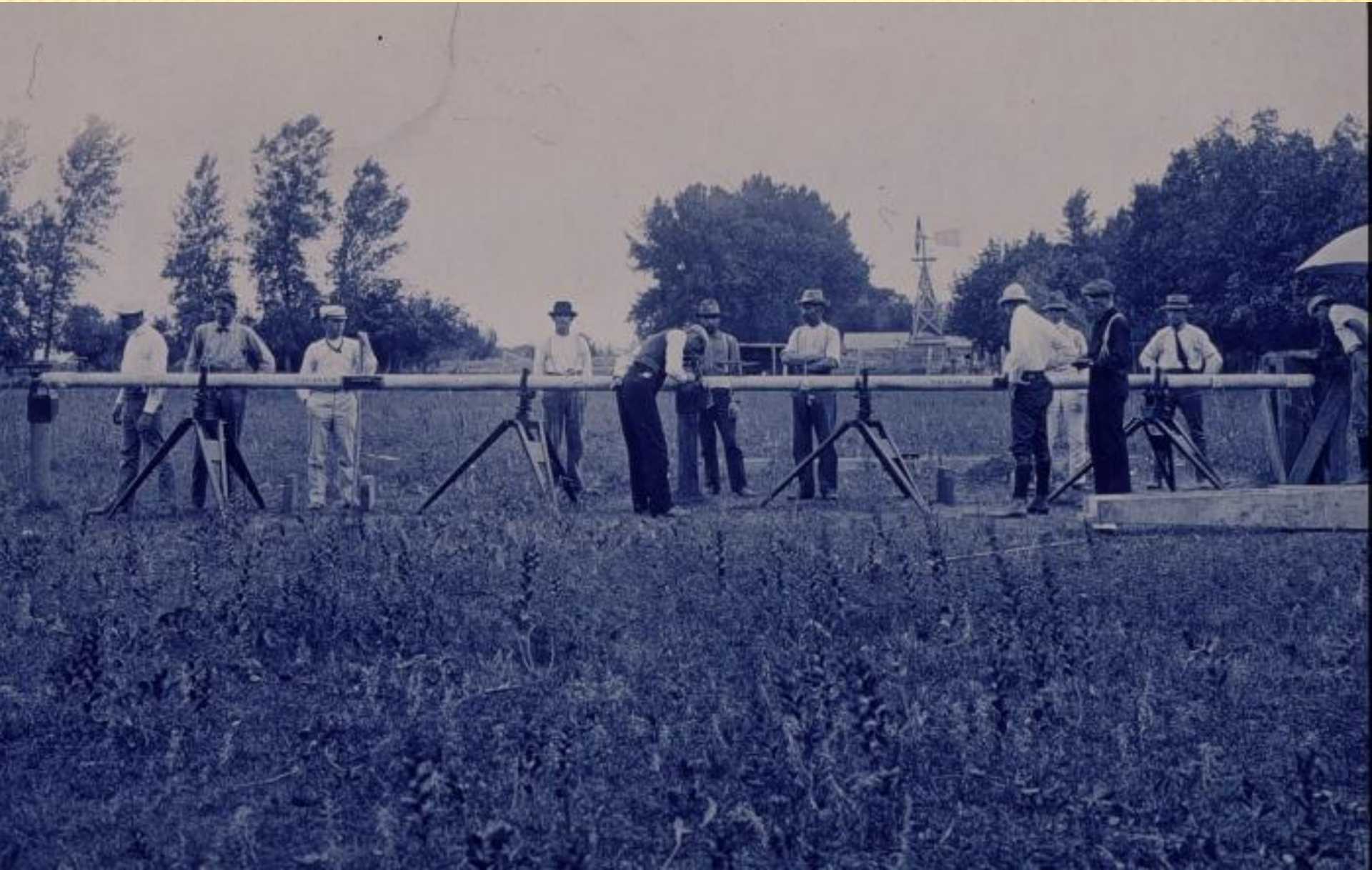


**Yolo Buggy used to transport and shade baseline
Measurement, Sacramento Valley, CA - 1881**

Salina, KS Baseline Measurement – 1896

6.5 km/4.1 mi required about 5 weeks

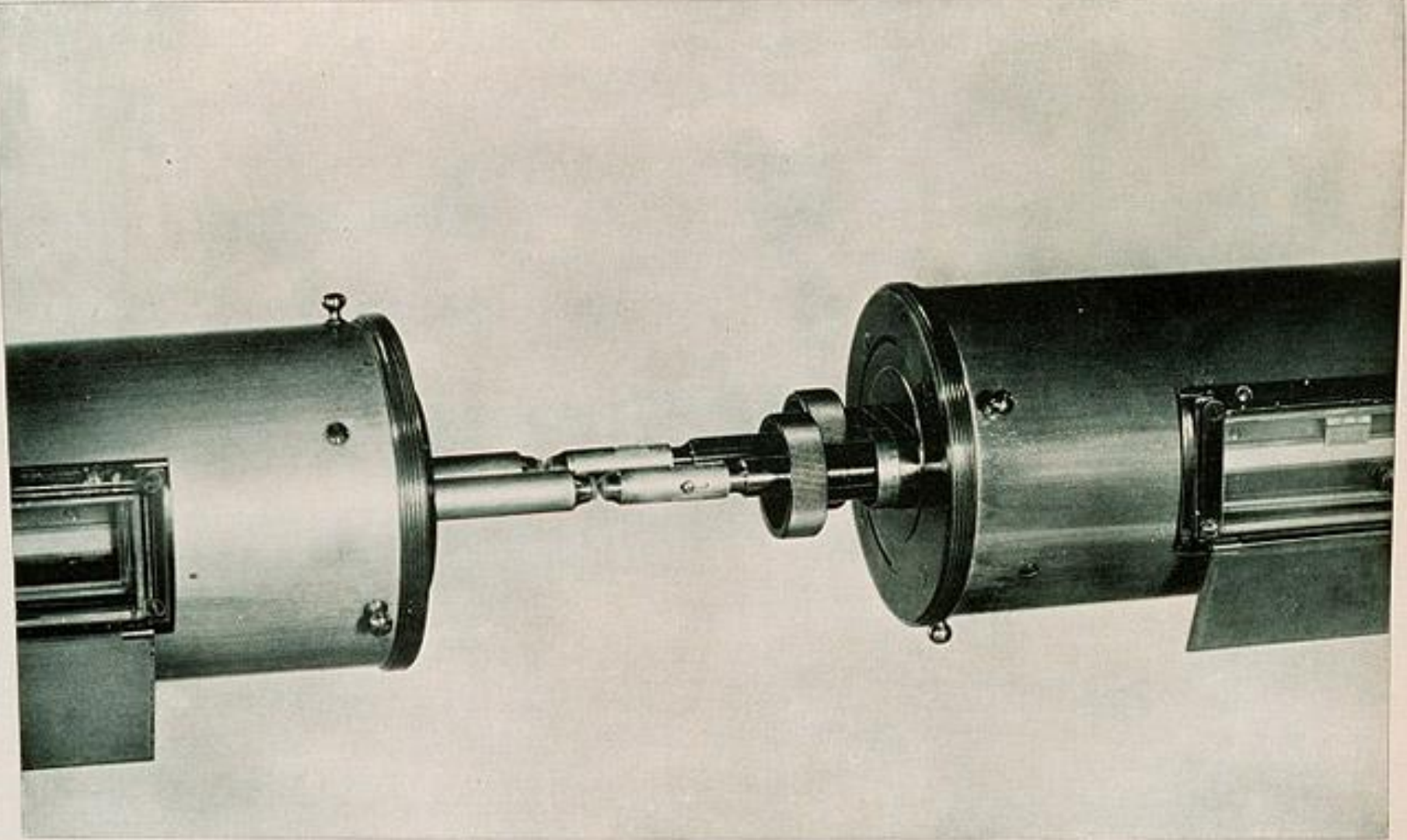
Precision ~ 8 mm/0.03 ft (1:721,600) [1 ft in 137 miles]



Cutting Edge Surveying Technology circa 1890

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

No. 3.



DUPLEX BARS IN CONTACT - FACE DOWN.

Advances in distance measurement technology

Early 1900s



Electronic technology 1950s - 1970

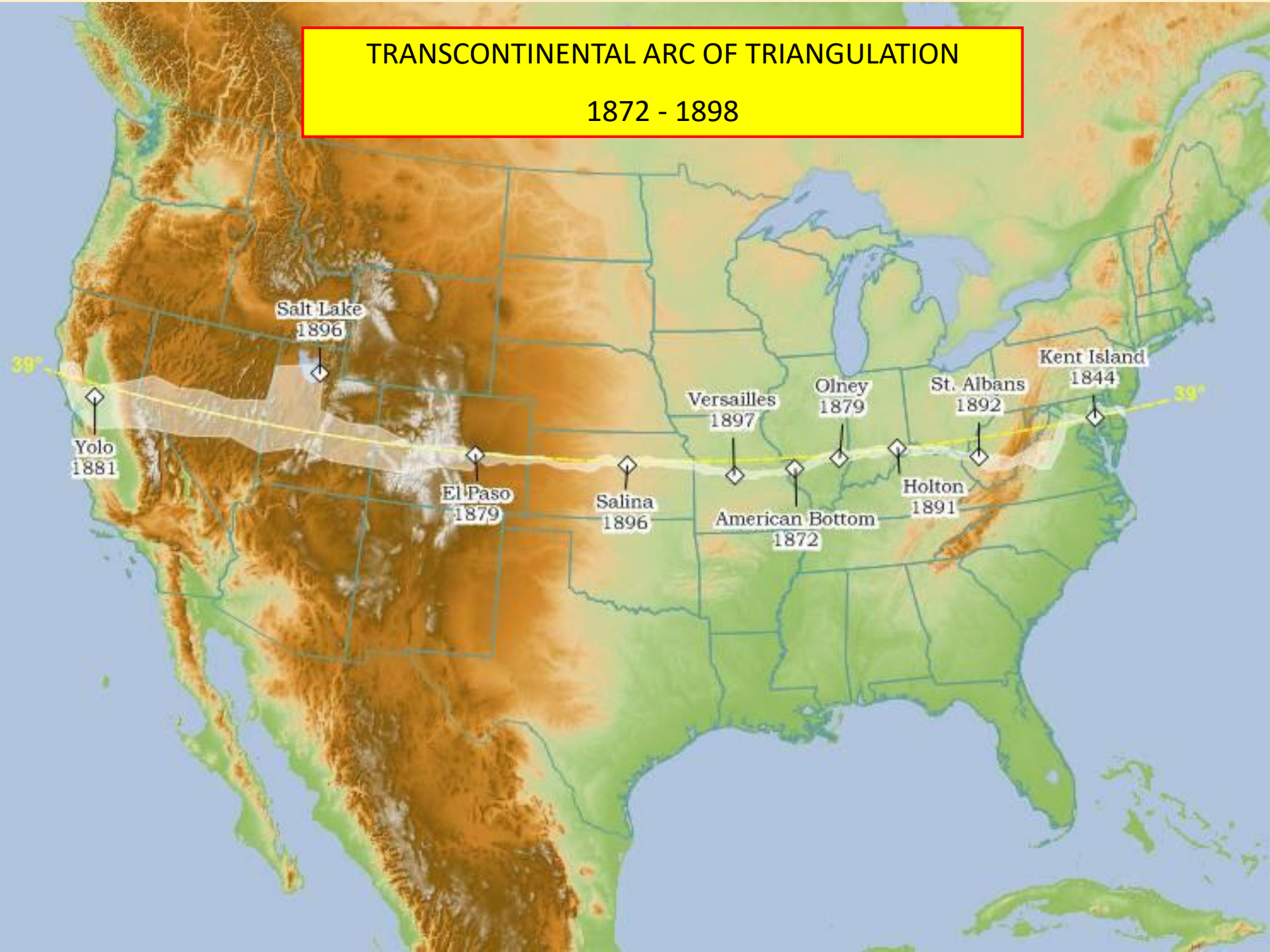


A Game Changer



TRANSCONTINENTAL ARC OF TRIANGULATION

1872 - 1898



Timber Towers



August 28 to September 22, 1885

Coast and Geodetic Survey—Transcontinental Triangulation

No. 41



HIGH SUMMIT STATION, TUSHAR MOUNTAIN, UTAH, SHOWING RING WALL AND DOUBLE SHELTER TENT AGAINST STORMS AND RADIATION OF HEAT.

Altitude, 3,702 meters or 12,146 feet.

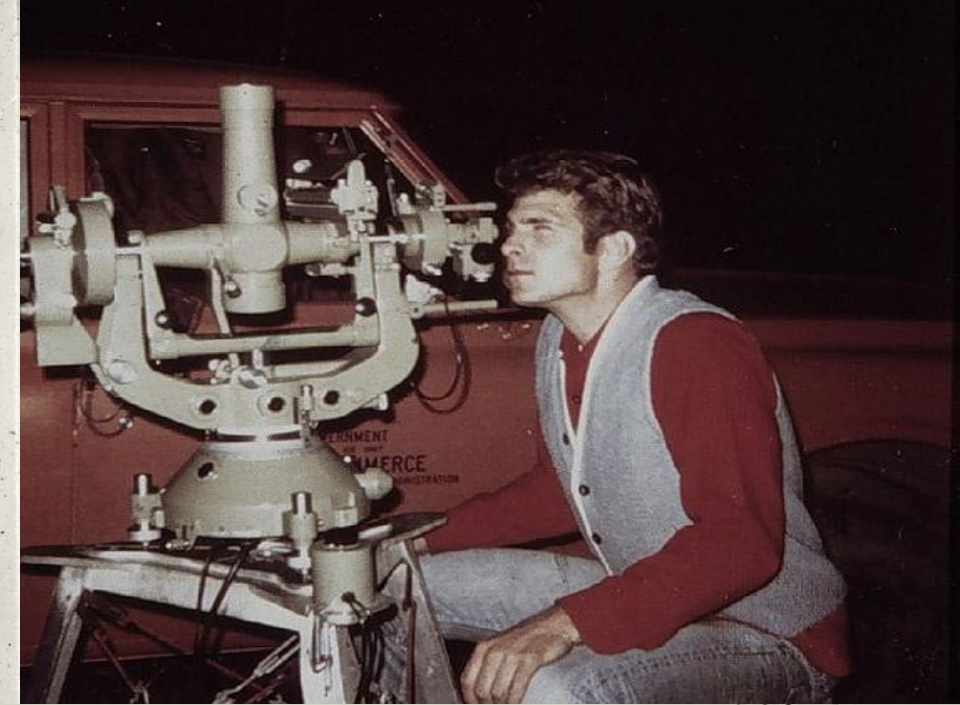
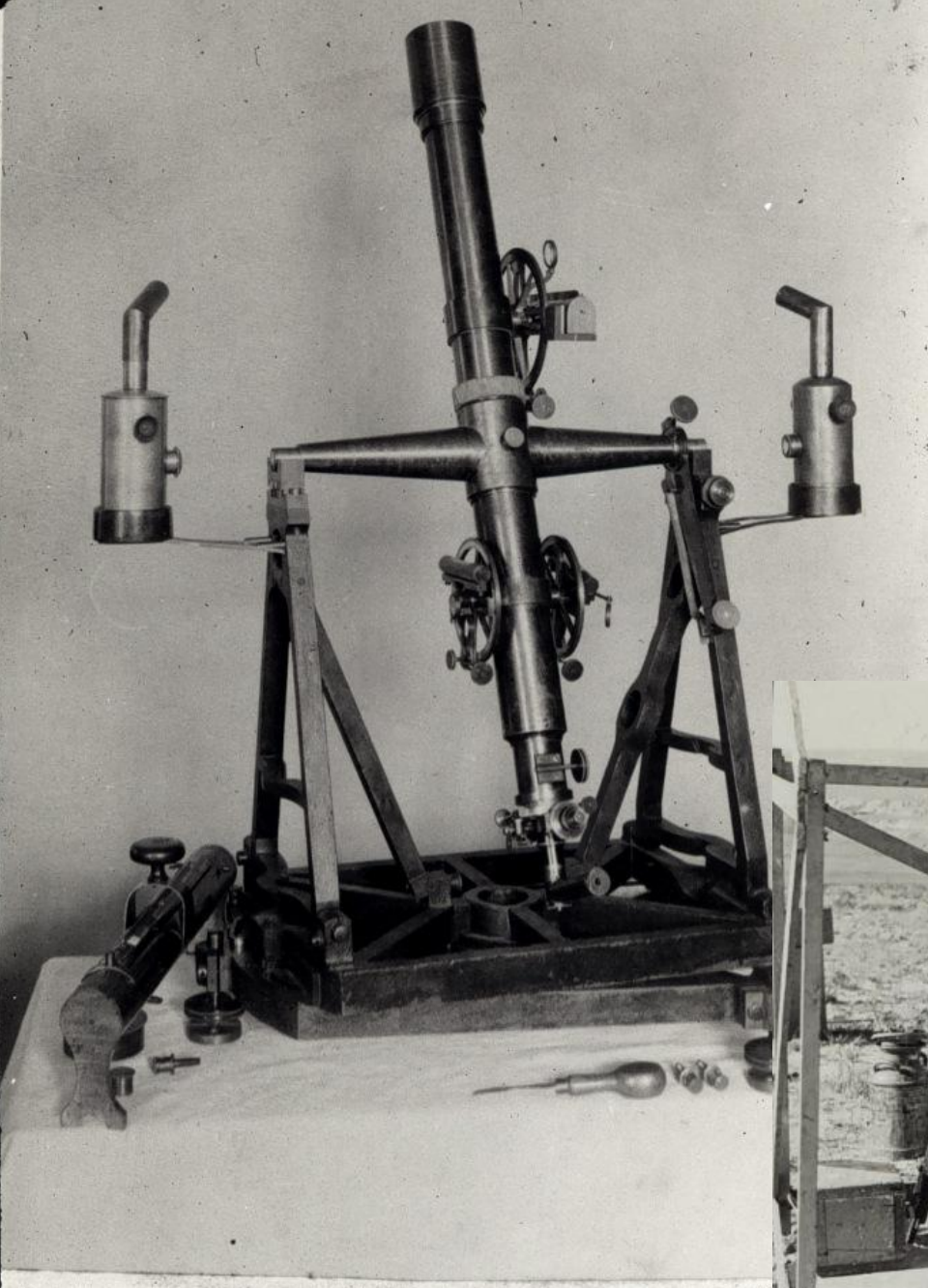
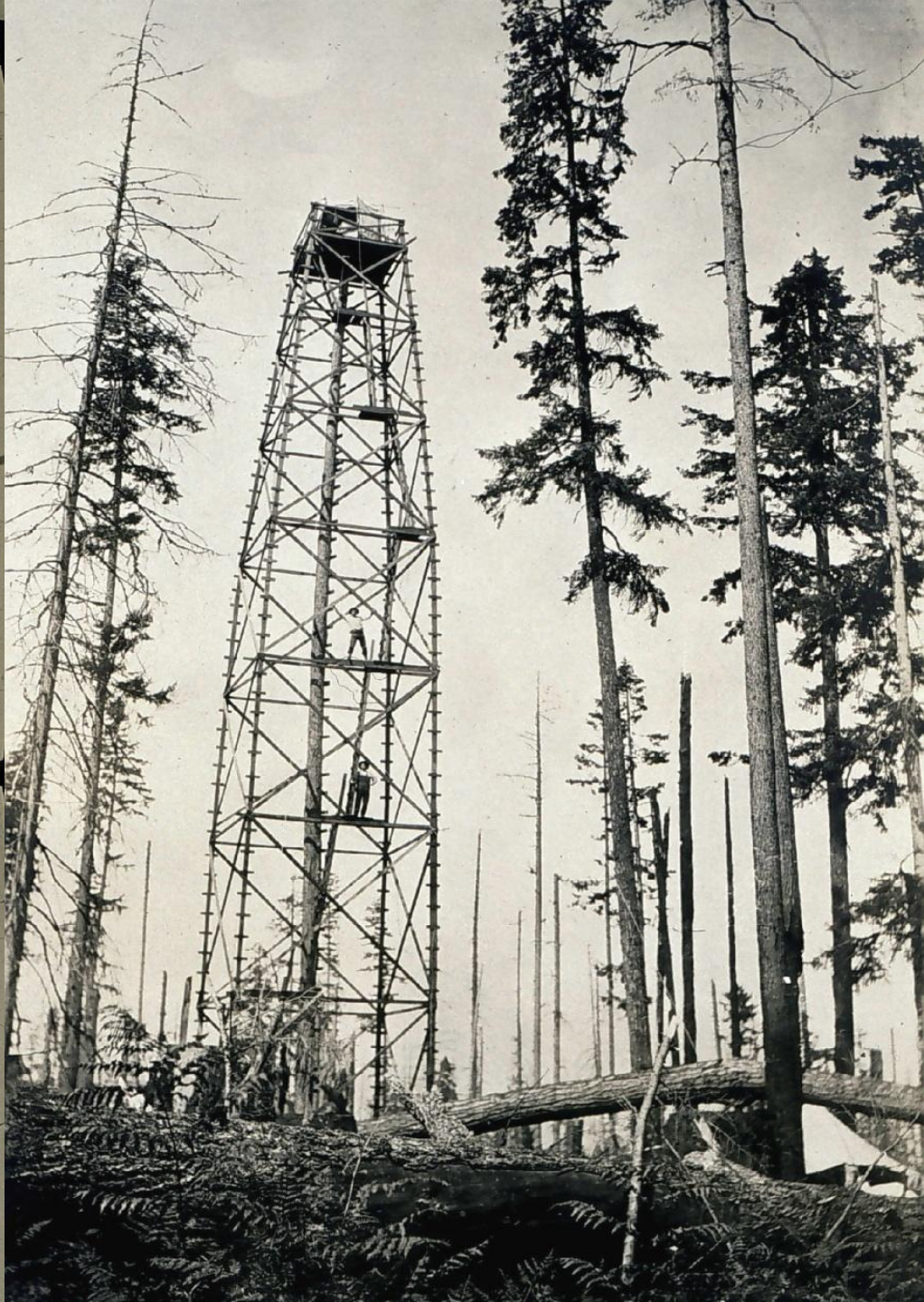
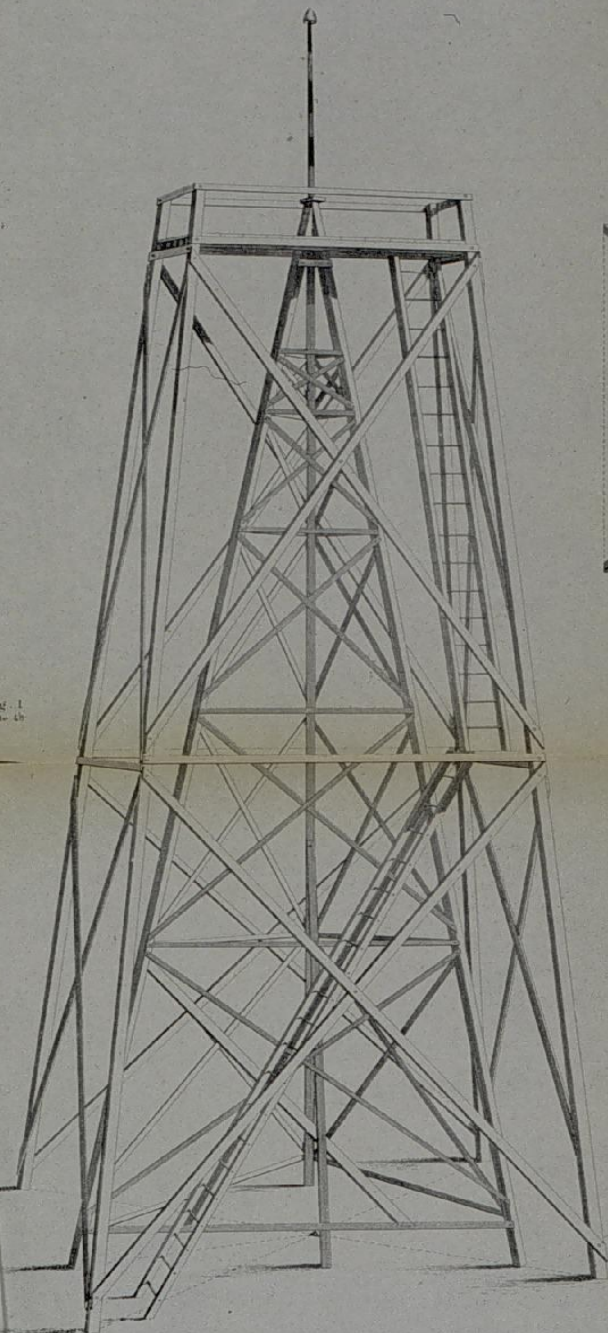


Fig. 1
Scale 40'



Jasper Bilby

Joins USC&GS in 1884



**JASPER
BILBY
1864-1949**



Bilby Tower

- ❖ VIEW OF TOP PORTION OF A BILBY TOWER
- ❖ LIGHTKEEPER AIMING 4 LTS
- ❖ OBSERVER PULLING TENT
- ❖ RECORDER SITTING
- ❖ ALL 3 PEOPLE SUPPORTED BY OUTER “BLUE” TOWER
- ❖ INSTRUMENT ON INNER “RED” TOWER

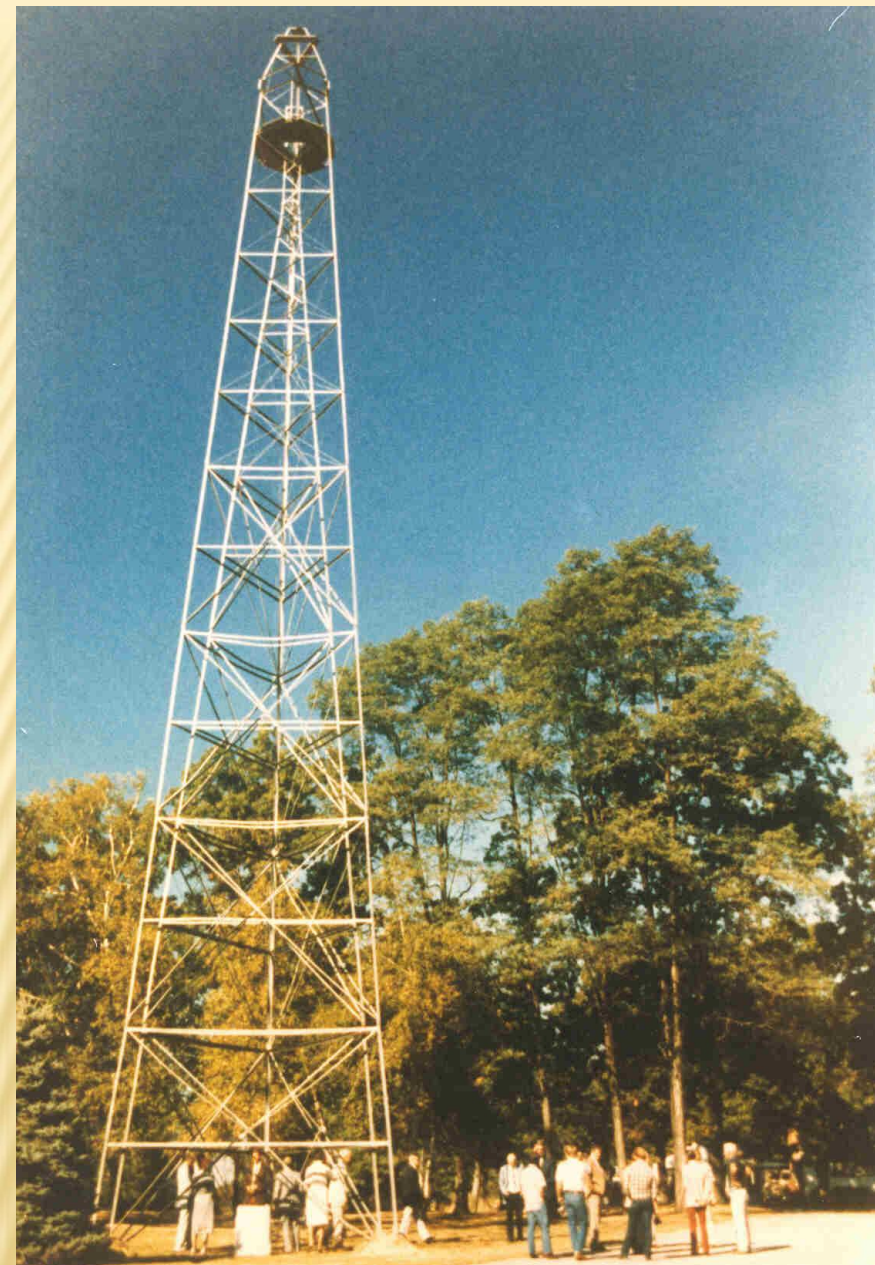




BILBY TOWER CONSTRUCTION

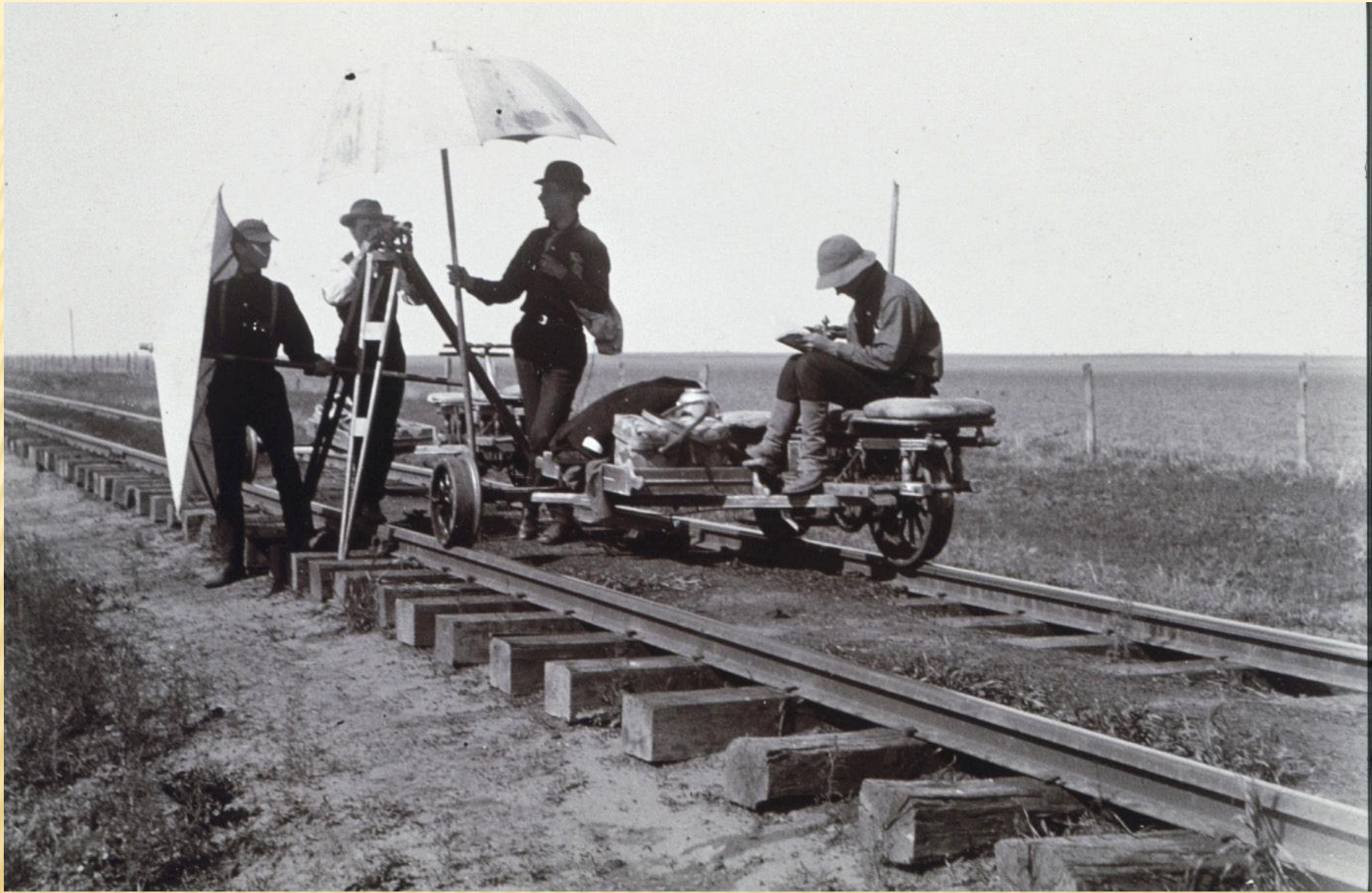
USC&GS/NGS Geodetic Nomads





1984 AN END OF AN ERA



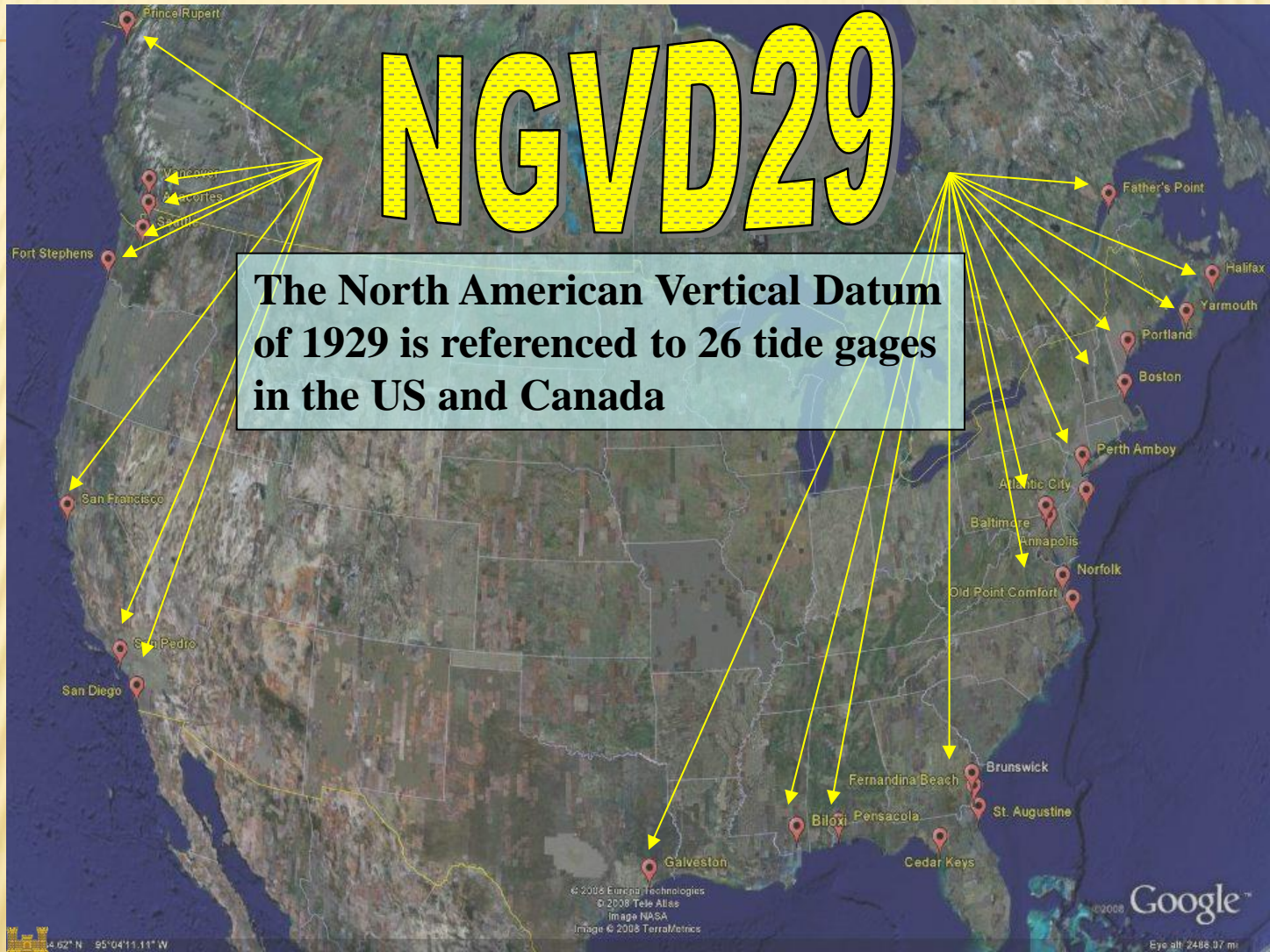


**CLASSICAL LINE-OF-SIGHT
SPIRIT LEVELING
1900**



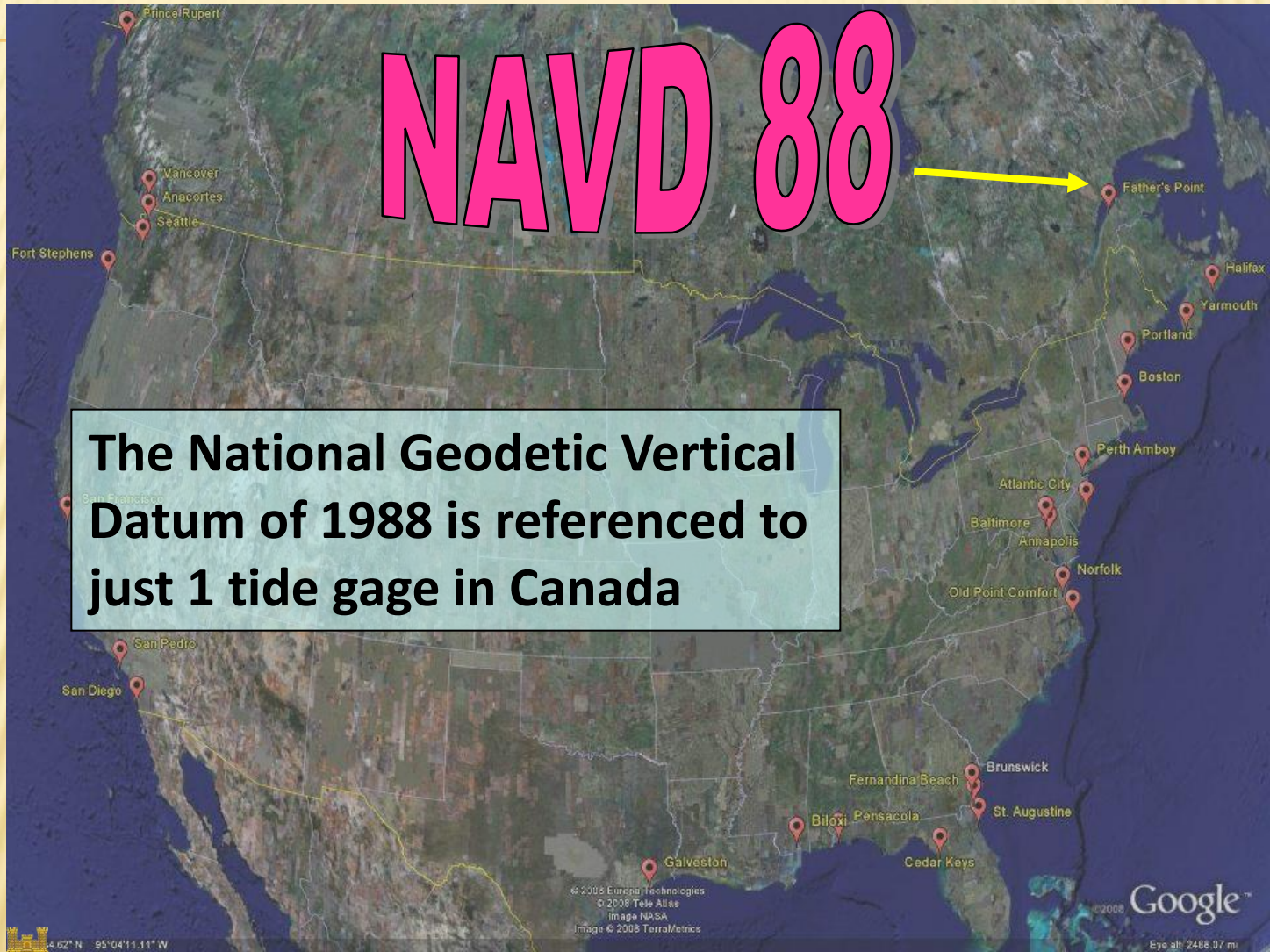
NGVD29

The North American Vertical Datum of 1929 is referenced to 26 tide gages in the US and Canada



NAVD 88

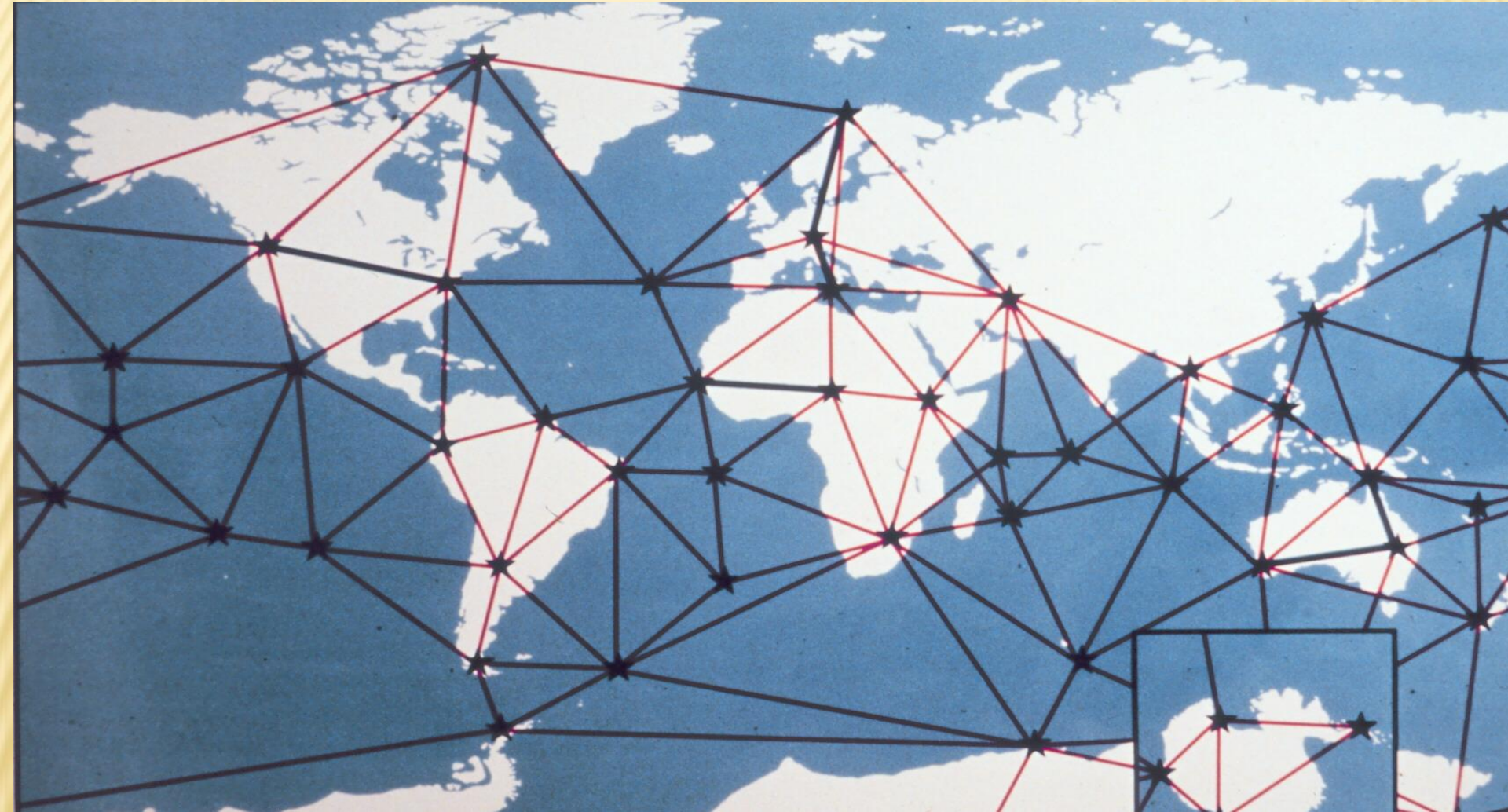
The National Geodetic Vertical Datum of 1988 is referenced to just 1 tide gage in Canada





SPUTNIK
October 4, 1957

Global Satellite Triangulation Network (BC-4) 1964-1973



Global Satellite Triangulation Network (BC-4) 1964-1973



Pitcairn Island



Ft. Lamy, Chad



NW Territory, Canada



Palmer Station, Antarctica



GLOBAL SATELLITE TRIANGULATION NETWORK

(BC-4)

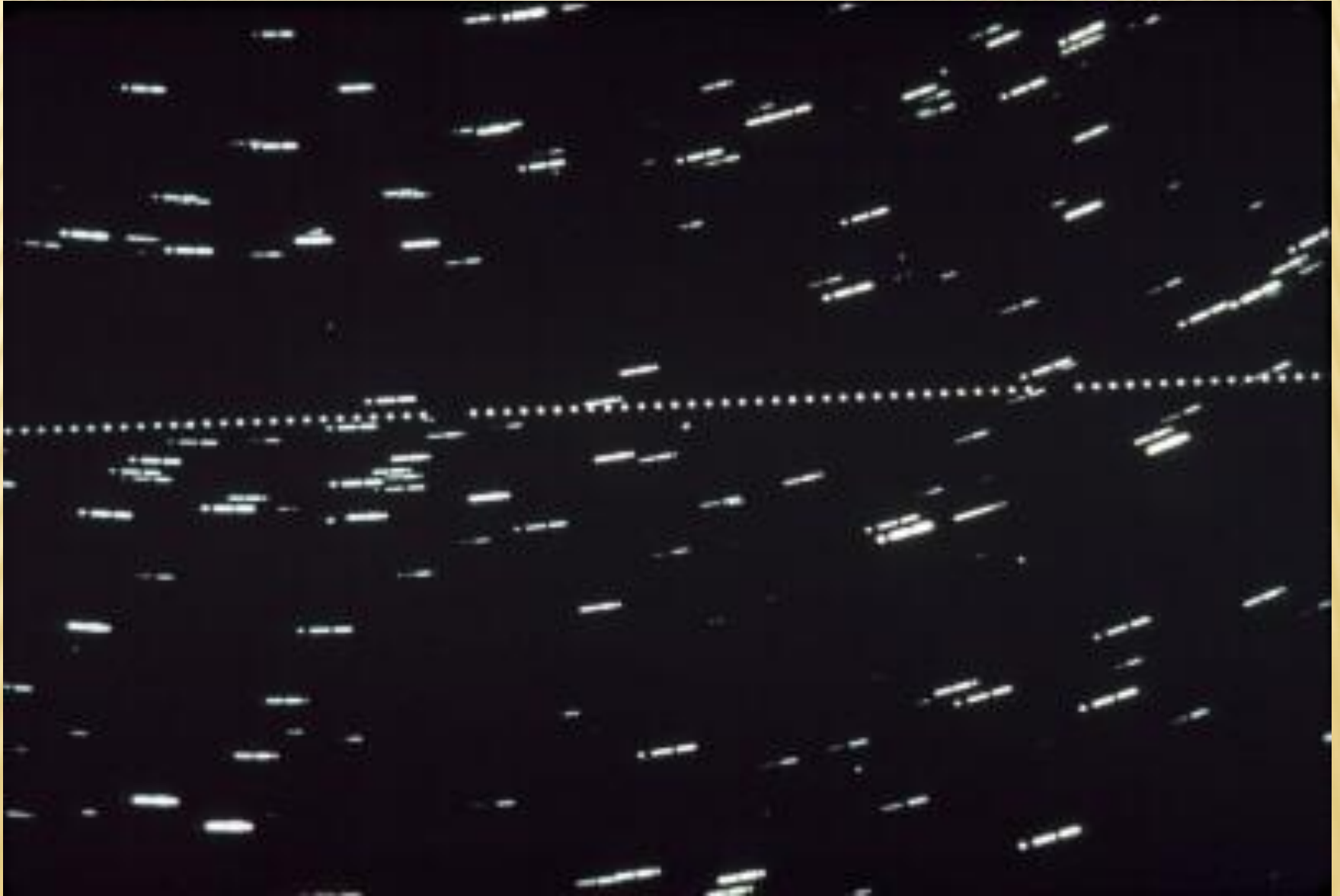
1964-1973

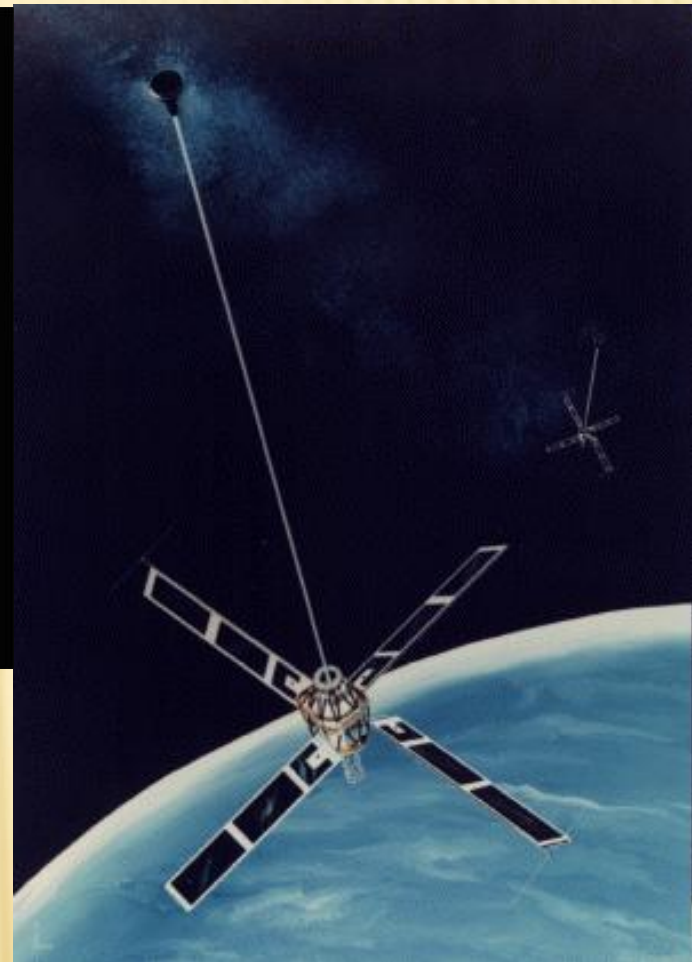
ECHO/PAGEOS Ballon Satellite Type Photographer by BC-4



BC-4 Camera Photograph

PAGEOS Satellite against the star background

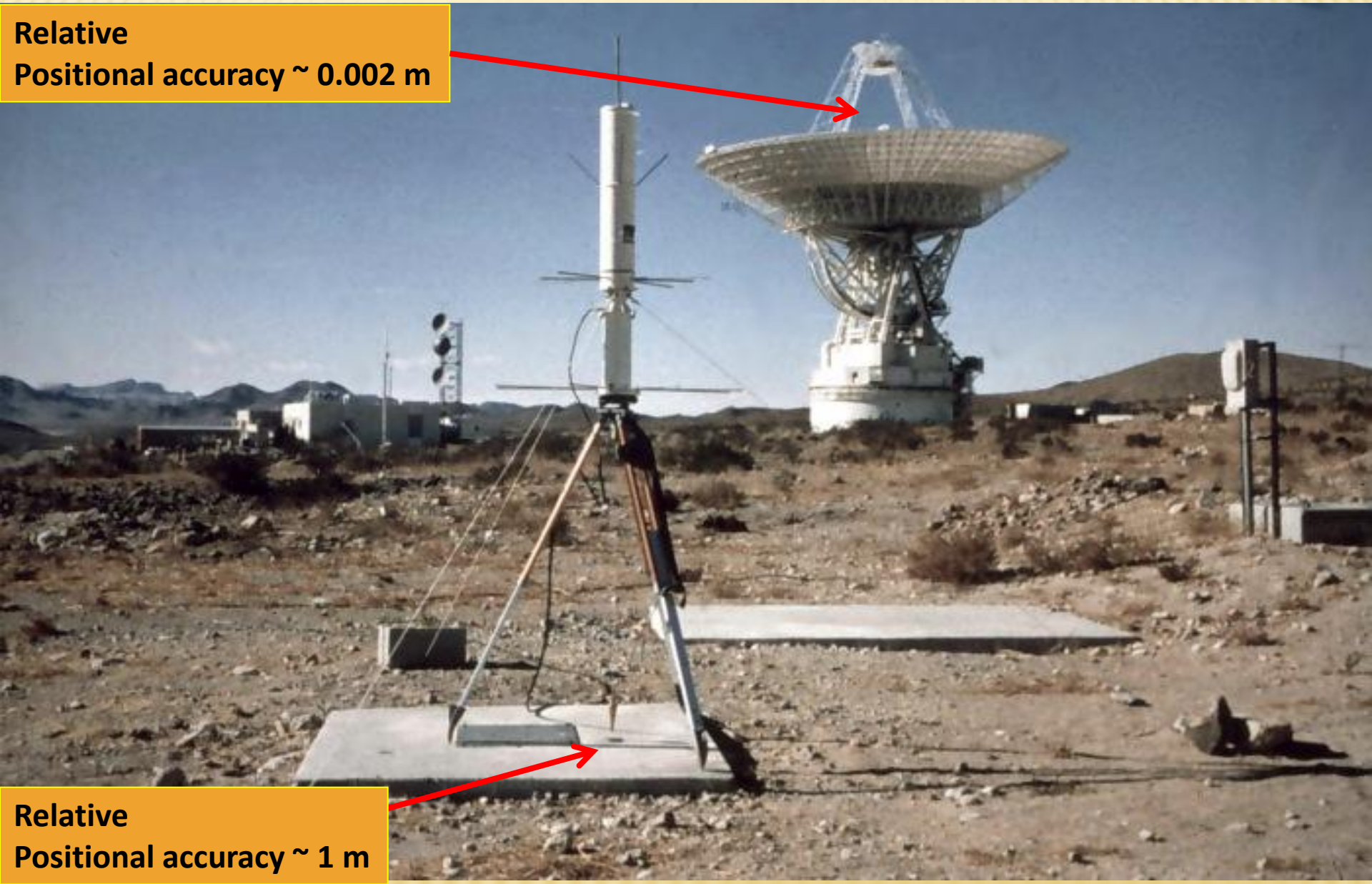




U.S. NAVY NAVSAT TRANSIT SATELLITE “Doppler”
Prototype Launched (Failed) 1959
First Successful Test 1960
Operational 1964 (Military)
Civilian Access 1967

Transit Geceiver and VLBI

Relative
Positional accuracy ~ 0.002 m



Relative
Positional accuracy ~ 1 m

International VLBI Network



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 2014 – First Block III scheduled for launch**
- **2020? - 10-50 cm real-time accuracy!**

Macrometer V-1000 GPS Receiver

1982 ~ approx. \$250,000 each



NAD 83 History in VA, MD, WV, NC, KY

1983 -- NAD 83 (1986) – All classical triangulation adjusted as part of new national geodetic horizontal datum. Approx 266,436 classical triangulation and traverse stations, including some Transit Doppler and VLBI. Required 12 years to complete. Subsequent GPS observations indicated NAD 83 suffered from approximately 1 m nation-wide distortion.

1991 -- NAD 83 (1991) – NGS observes the MD High Accuracy Reference Network (HARN). All classical triangulation adjusted to fit HARN.

1993 -- NAD 83 (1993) – NGS observes the VA & KY High Accuracy Reference Network (HARN). All classical triangulation adjusted to fit HARN.

1995 -- NAD 83 (1995) – NGS observes the NC & WV High Accuracy Reference Network (HARN). All classical triangulation adjusted 93to fit HARN

2000 -- VA, MD & WV, MD observed as part of the Federal & Cooperative Base Networks (FBN/CBN), 2002 KY observed. All passive GPS stations left alone pending inclusion in 2007 national adjustment.

2001- NAD 83 (2001) NC reobserved by NGS and NCGS as part of the Federal & Cooperative Base Networks (FBN/CBN). All passive GPS adjusted to new coordinates; classical triangulation not adjusted.

2007 -- NAD 83 (2007) – All passive GPS control adjusted to fit update CORS network positions – 67,000+ stations

2011 -- NAD 83 (2011) – All passive GPS control adjusted to fit update CORS network positions – 80,000+ stations



24 Horizontal Datums of the US

Bessel Coordinates (1851–1878) – Coordinates derived from locally defined astronomic observations – All computed on the Bessel 1841 Ellipsoid

New England Datum (1879–1900) – First to use Clarke 1866 ellipsoid, origin of coordinates station PRINCIPIO 1845 in Maryland

U.S. Standard Datum (1900–1913)
North American Datum (1913–1927)
North American Datum 1927 (1927–1986)

Clarke 1866 ellipsoid
Origin – MEADES RANCH 1891
Kansas

Alaska Datums (14 Different 1890–1954)
Puerto Rico Datum (1901–1986)
Old Hawaiian Datum (1928–1986)
American Samoa Datum (1962–1993)
Guam Datum 1963 (1963–1993)

Clarke 1866 ellipsoid
Origin – Local Astro station in
each area

North American Datum 1983 (1983–Present) – First to use GRS80 ellipsoid and origin of coordinates at Earth Mass Center

12 Vertical Datums of the US

North American Vertical Datum 1988 (1991-Present)

National Geodetic Vertical Datum 1929 (1973-1991)

Sea Level Datum 1929 (1938-1973)

1929 General Adjustment (1929-1938)

Fourth General Adjustment (1912)

Third General Adjustment (1907)

Second General Adjustment (1903)

First General Adjustment (1899) -- (A.K.A. Sandy Hook Datum)

American Samoa Vertical Datum 2002

Puerto Rico Vertical Datum 2002

Northern Marianas Vertical Datum 2003

Guam Vertical Datum 2004

Virgin Islands Vertical Datum 2009

Hawaii – Local Mean Sea Level, each island

GOOD COORDINATION BEGINS WITH GOOD COORDINATES



GEOGRAPHY WITHOUT GEODESY IS A FELONY