National Geodetic Survey

VT State Plane

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STATE PLANE COORDINATES

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R. P. PATTON · Director

STATE-WIDE SYSTEMS OF PLANE COORDINATES[1]

O. S. Adams

The U.S. Coast and Geodetic Survey has established a nation-wide network of arcs of triangulation that at the present time has a total length of some 65,000 miles. These arcs are fairly evenly distributed throughout the country and they thus form the basis for the control of further surveys that may be made locally or regionally wherever the data are readily accessible. Experienced engineers and surveyors realize the fundamental importance of rigid checks on any observational data. In an independent survey certain checks can be afforded by the methods of observation but an external check by means of work that has already been established and shown to be correct by various checks in the net to which it belongs, is of the greatest importance in all such subsidiary surveys.

Much remains yet to be done in the establishment of these fundamental Federal surveys. In spite of the fact that, during the past few years, there has been a rapid expansion of the horizontal control net of the nation, very much more remains to be done. There are large areas that are not now supplied with the fundamental data. The rapidity with which the national net may be completed will depend almost entirely upon the demands made on the Federal Government by engineers, planners and others who may require the horizontal control survey data in the execution of their work.

In addition to the data established by the Coast and Geodetic Survey, there are many surveys that have been made by other bureaus of the Government, such as the Geological Survey, the Army Engineers etc. Whenever these surveys are properly tied in with the fundamental net of the Coast and Geodetic Survey showing an error of closure acceptable for first-, second- or third-order surveys, they in turn may become control data for subsequent work. In sum total, therefore, there exist many thousands of stations that are accurately located and correlated to each other scattered fairly evenly over the country.

1 Paper read before the Surveying and Mapping Division of the American Society of Civil Engineers, Pittsburgh, Pa., October 14, 1935. Abstract of paper appears in the January number of CIVIL ENGINEERING

In view of this fact, it is of supreme importance to arouse the interest of engineers and surveyors throughout the country in the great advantages to be gained by basing local and regional surveys on this fundamental control. Since this control net is so extensive and reaches from one end of the country to the other, it is necessary to take into account the curvature of the earth in the computations. The final data are consequently expressed in terms of latitude and longitude and in azimuths and lengths. These geodetic computations are rather involved and it generally requires some study before they can be made with ease and certainty by even well trained engineers and surveyors. The actual computations are not so difficult but if one wishes to delve into the theory upon which they are based, the mathematics involved is often beyond the grasp of those who may wish to understand fully the significance of the computations.

The Coast and Geodetic Survey has tried for fifty years more or less to encourage the use of control surveys in the form of geodetic positions among the engineering profession. While in certain instances we met with success, on the whole the batting average was very low. Although I am sure that many were needlessly frightened off by an exaggerated view of the difficulties to be encountered, yet the fact still remains that they were frightened off and as a result failed to take advantage of the control surveys. A wise general, when he does not meet with full success in one method of attack, will change his tactics and seek to attain his objective in some other way.

During 1932 and 1933, the Coast and Geodetic Survey cooperated with the State of North Carolina in the completion of the first-order horizontal control in that State. Early in 1933, Mr. George F. Syme, of the State Highway and Public Works Commission, requested us to consider the possibility of setting up a system or systems of plane coordinates for the State. At the request of Dr. William Bowie, Chief of the Division of Geodesy, I undertook a study of the possibilities for the State. While working on the project, I had several conferences with Colonel C. H. Birdseye of the U.S. Geological Survey, who was much interested in the subject of plane coordinates for use in State-wide survey operations. As a result of my study and of the various conferences, the system for North Carolina was devised. Not long after the computation of the tables occurred the tragic death of Mr. Syme and the direction of the work in the State passed into the hands of Mr. O. B. Bestor, who has been carrying on survey operations in the State with the coordinates of the triangulation stations on the State system used as control of his local surveys. Several thousand miles of traverse have been run and computed on the plane with no greater complications than those involved in latitudes and departures.

This was, therefore, the start of the computation of tables for State-wide systems of plane coordinates, a computation which was undertaken at the request of a practical engineer and surveyor. What I wish to convey is the fact that the incentive for the initiation

of such schemes came from engineers outside of the Government departments and not as a result of a brain storm of some theoretical mathematician and geodesist.

After the coordinates of the control stations have been computed, it scarcely makes any difference on which of the two projections the computations were based. The method of using the coordinates is essentially the same on both of the systems and the computation of surveys by plane coordinates is about the same on either system. The method of traverse computation by means of latitudes and departures is familiar to all who have studied plane surveying and is in general use among surveyors and engineers in some form or other.

In almost all of the systems, the aim was to keep the variations of scale within one part in 10,000. This limit was slightly exceeded in the North Carolina system because the engineers in that State preferred to let the departure exceed this limit rather than have the State divided into two zones. In the computation of third-order traverses it is probably not necessary to take into account these variations of scale. In the most accurate work, however, it is advisable to correct the measured lengths for this variation of scale before computing a given traverse.

Since in both systems of coordinates the reductions to coordinates are made from geodetic positions, the sea-level lengths are involved in the starting data. There are, therefore, two separate reductions that should be applied to measured lengths before they are employed in the computation of a traverse, if the most accurate results are required. That is, the lengths should first be reduced to sea level and then a correction should be applied for the variation of scale on the grid. These grid variations are listed for every minute of latitude on the Lambert grids and for every 5,000-foot distance from the central meridian on the transverse Mercator grids. It is thus a very easy matter to determine this grid correction for any given line and in most cases it is sufficiently accurate to determine a mean correction for any given traverse. For a traverse that is properly tied in with the control, there will be a starting station and an ending station for which the coordinates will be given. By consideration of these coordinates it is very easy to determine from the coordinate tables just what mean grid factor may be required for the measured lengths of the traverse in consideration.

A number of the States have already made very extensive use of the coordinates in their local work. The use of the grid was started at once in North Carolina and it is still in active use for all local surveys under the direction of Mr. O. B. Bestor. In New Jersey the system has been used extensively in the computation of local traverses and under the able direction of Professor Philip Kissam of Princeton University, a law has been passed that legalizes the definition of property boundaries in terms of the coordinates of the angle points of the property. This is a significant advance both in the interest of the coordinate systems and in the interest of cadastral surveying in the State, and it forms an important advance in the method of the definition of property boundaries.

The coordinates in Tennessee are in wide use by the various divisions of the Tennessee Valley Authority. Traverses are being computed directly on the grid and the corners of all Government purchases of property are being tied in with the State system of control. This method fixes for all time the exact location of these points. If at any future time the marks at any of them should be destroyed, they could be restored by means of their coordinates. Monuments, even of the most permanent type, may be destroyed in time but the coordinate relations still persist and the actual situation of the monument can be relocated and remonumented in all cases of loss by destruction of the mark.

Extensive use is being made of the coordinates in North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee, Louisiana, New Jersey, Connecticut, Massachusetts, Iowa and many other States. An accurate map of Denver and vicinity is being made by the U.S.Geological Survey under an appropriation of the Works Progress Administration and the work is being based on the Colorado grid.

The matter of city surveys brings up the question regarding sea level and ground level, or rather, whether grid scale should be used, or a scale on a mean ground-level plane. It seems to me that the importance of having the work tied in with the control net far outweighs the need for exact ground level distances. A circular letter was sent to a number of representative engineers and surveyors to get a general recommendation on this very point. Most of the replies that we received looked at the matter in the same way as we had considered it. Actual lengths and areas can easily be determined from a map made on the State grid even though the coordinates may give slightly different results. Denver is probably at a higher elevation than any other large city in the country and, if its engineers find the use of the State grid satisfactory for their work, it should be equally so for any other such city in the country.

It is our opinion that all local surveys that consist merely of traverse can be computed on these State-wide plane coordinate grids with much less effort than would be required by any other method. If, however, a local survey is carried on by means of triangulation, then it is probably simpler and more economical to compute the work geodetically. Triangulation can be computed and adjusted on the grid but the calculations required are equal if not greater than would be required by the geodetic method. Of course, if any engineers or surveyors wish to compute all of their work geodetically, we would not desire to discourage them, if they will base their work on the Federal control surveys. We think, however, that they would be overlooking a great advantage if they did not use the grid for their traverse computations.

The members of the Corps of Engineers, U.S.Army, are becoming much interested in the State grids and they are actually using them

Today’s Outline

- Define the problem
- Review of VT State Plane System
- Relationship of field (Horizontal) and grid distances
- Relationship of orientation systems
- Documentation

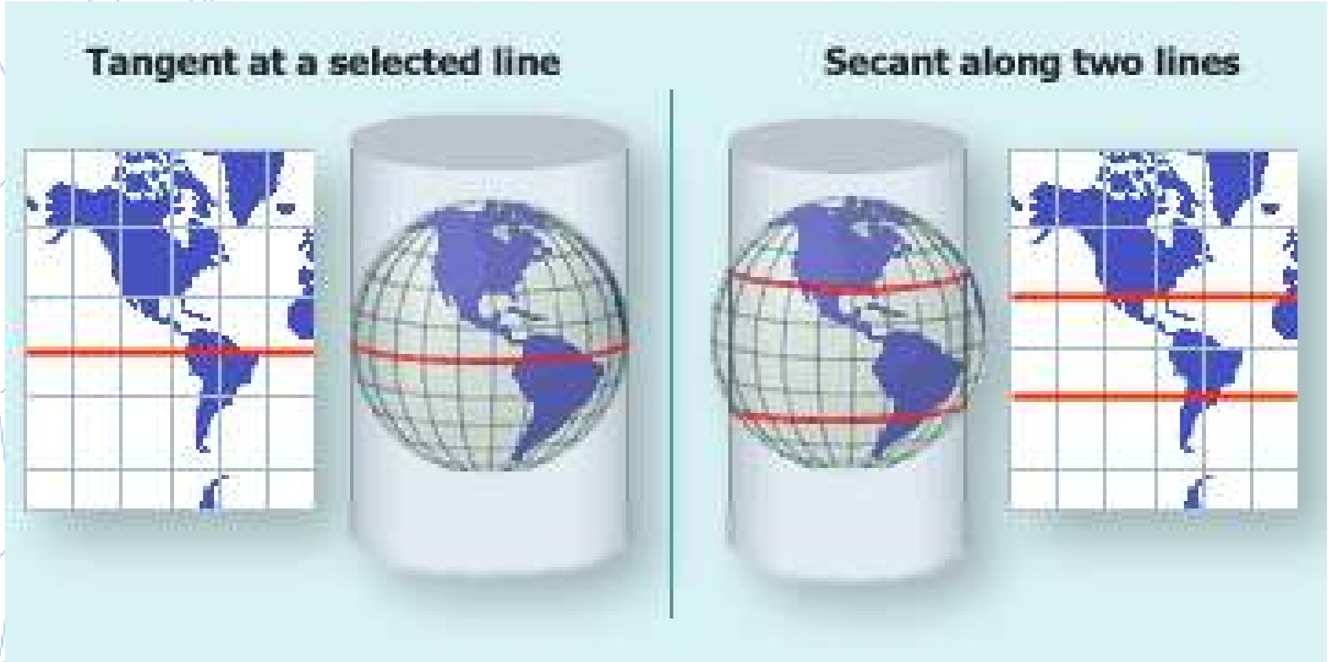
What is the problem…Why are we having this discussion?

- General lack of understanding today compared to the past
- More users of SPC today than in the past
  - GPS
  - OPUS, OPUS-RS
  - Computers, Software
  - Easy transfer of data from one technology to another
- Real time or near-real time access to coordinates
- Many different realizations of the datum/SPC

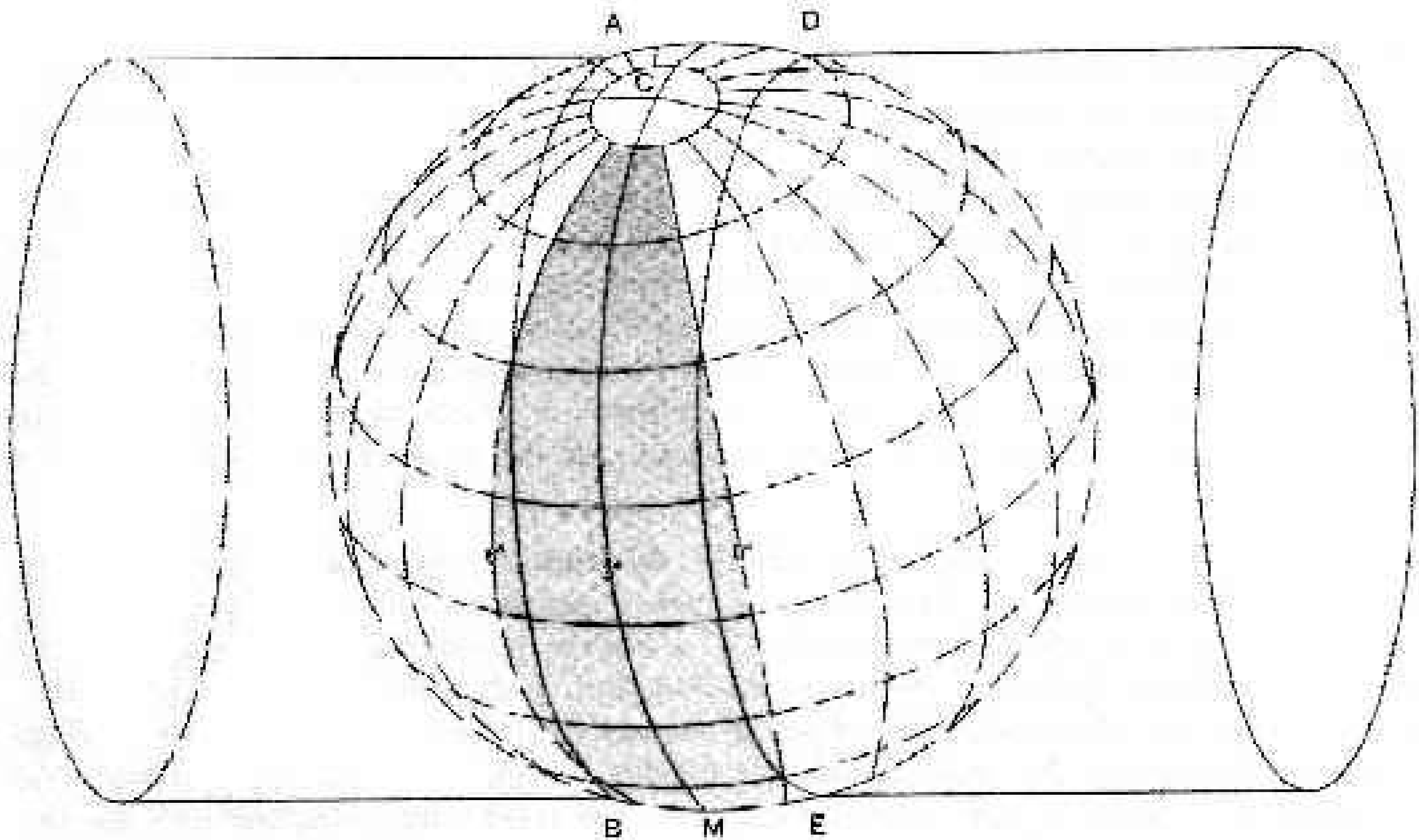
What is VT SPC System (defined)

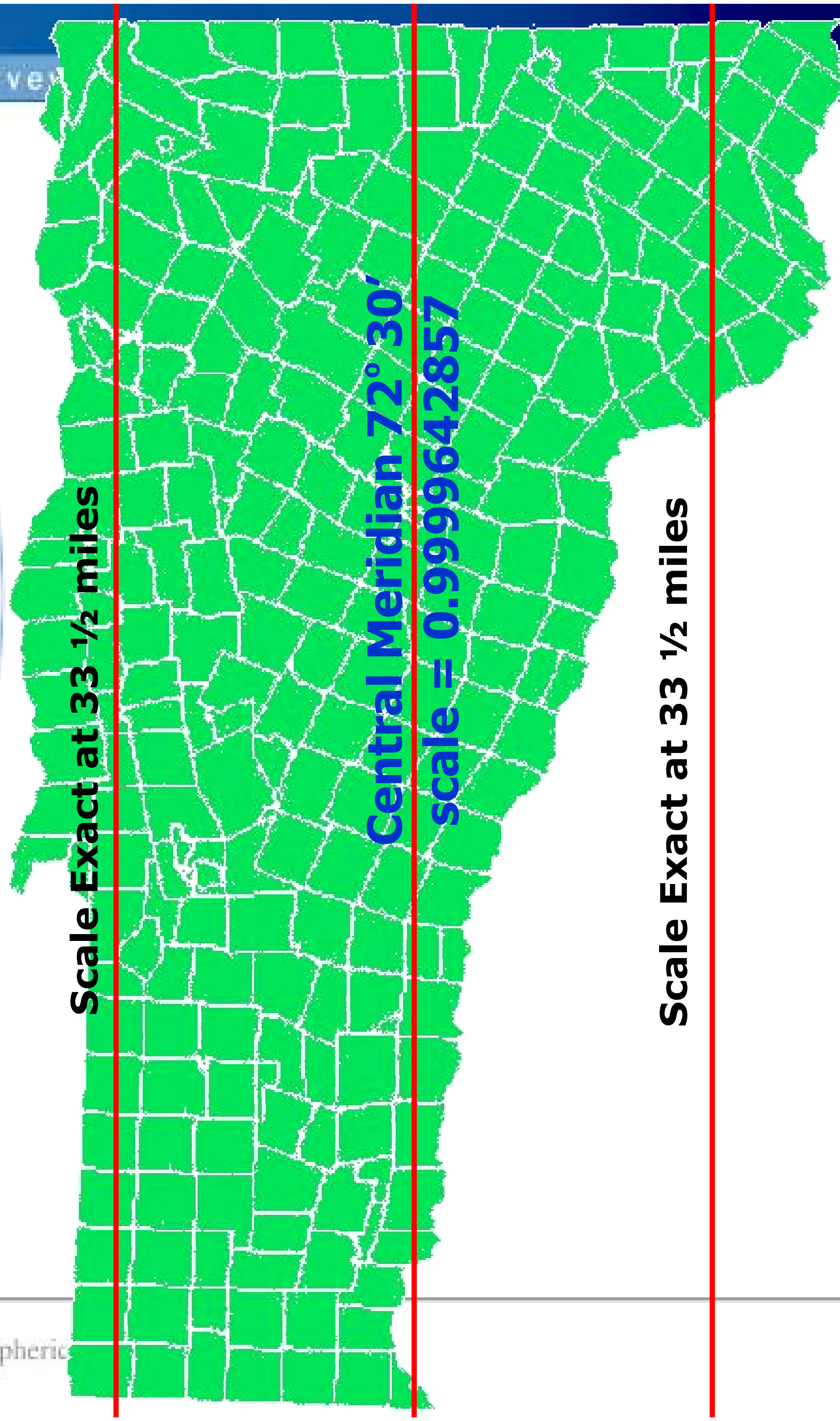
- Transverse Mercator Projection
- Central Meridian (CM) at 72°-30′
- False Easting at CM 500,000 meters
- Scale at CM 1:28,000 (0.99996429)
- Latitude of origin 42°-30′
- False Northing at Latitude of origin 0 meters

Mercator Projections



Transverse Mercator Projection (secant)




Scale Exact at 33 ½ miles
Central Meridian 72° 30′
scale = 0.999964285 7
Scale Exact at 33 ½ miles

State Plane
NAD27 vs. NAD83

NAD27

- Lat of origin 42°-30′
- Lon of CM 72°-30′
- Scale at CM .99996429 (1:28,000)
- False Easting 500,000 US Survey Feet
- False Northing 0.0 US Survey Feet
- Altitude reference **sea level**

NAD83

- Lat of origin 42°-30′
- Lon of CM 72°-30′
- Scale at CM .99996429 (1:28,000)
- False Easting 500,000 **meters**
- False Northing 0.0 **meters**
- Altitude reference **GRS80 Ellipsoid**

A Note About Conversions

- Be Careful when converting between feet and meters as there are two different systems of feet, the US Survey foot 1200/3937 (.3048006096 m/ft and the International Foot (.3048 m/ft exact)
- "The U.S. Metric Law of 1866 gave the relationship one meter = 39.37 inches. From 1893 until 1959, the yard was defined as being exactly equal to 3600/3937 meters, and thus the foot was defined as being exactly equal to 1200/3937 meters.
- 500,000 meters = 1640419.948 IF
- 500,000 meters = 1640416.667 SF
  - 3.28 feet difference
- Most States use the US Survey foot….but some use the International Foot (Vermont WILL use SF)

The Vermont Statutes Online

Title 1: General Provisions
Chapter 17: Vermont Coordinate System

672. Coordinates defined

§ 672. Coordinates defined

The plane coordinate values for a point on the earth's surface, used to express the horizontal position or location of such point on the Vermont Coordinate Systems, shall consist of two distances, expressed in U.S. Survey feet and decimals of a foot when using the Vermont Coordinate System 1927 and expressed in **meters and decimals of a meter when using the Vermont Coordinate System 1983.** One of these distances, to be known as the "x-coordinate," shall give the position in an east-and-west direction; the other, to be known as the "y-coordinate," shall give the position in a north-and-south direction. These coordinates shall be made to depend upon and conform to plane rectangular coordinate values for the monumented points of the North American Horizontal Geodetic Control Network established by the United States Coast and Geodetic Survey, its predecessor, or its successors. (Amended 1987, No. 169 (Adj. Sess.), § 2, eff. May 3, 1988.)

NAD 83 (Which One??)

- NAD 83 (Lat-Lon) SPC
  - Which one???
    - NAD 83 (1986)
    - NAD 83 (1992)
    - NAD 83 (1996)
    - NAD 83 CORS96(2002)
    - NAD 83 (NSRS2007)

Changes Over Time

- NAD83(86) based on old observations and new system vs. NAD27
- NAD83(92) based on new and old observations and same system
- NAD83(96) based on better observations and same system
- NAD83(CORS96) realization for CORS
- NAD83(NSRS2007) based on new observations and same system. Removed regional distortions and made consistent with CORS

Horizontal vs. Grid Distance

S=ellipsoidal distance

D= horizontal distance

R=mean earth radius

N=geoid height

H=orthometric height

h=ellipsoid height

K_{12}=line Grid Scale Factor (SF)

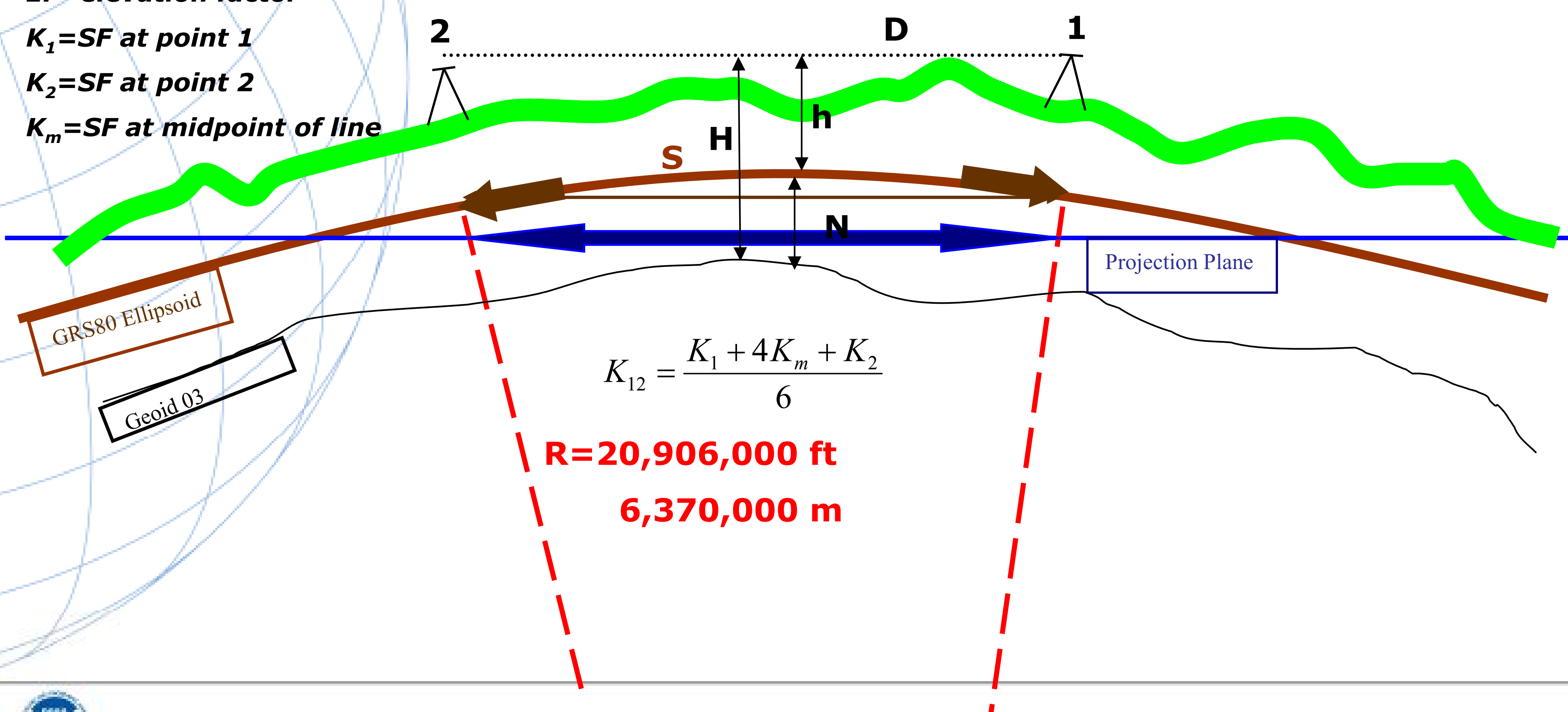
EF=elevation factor

K_1=SF at point 1

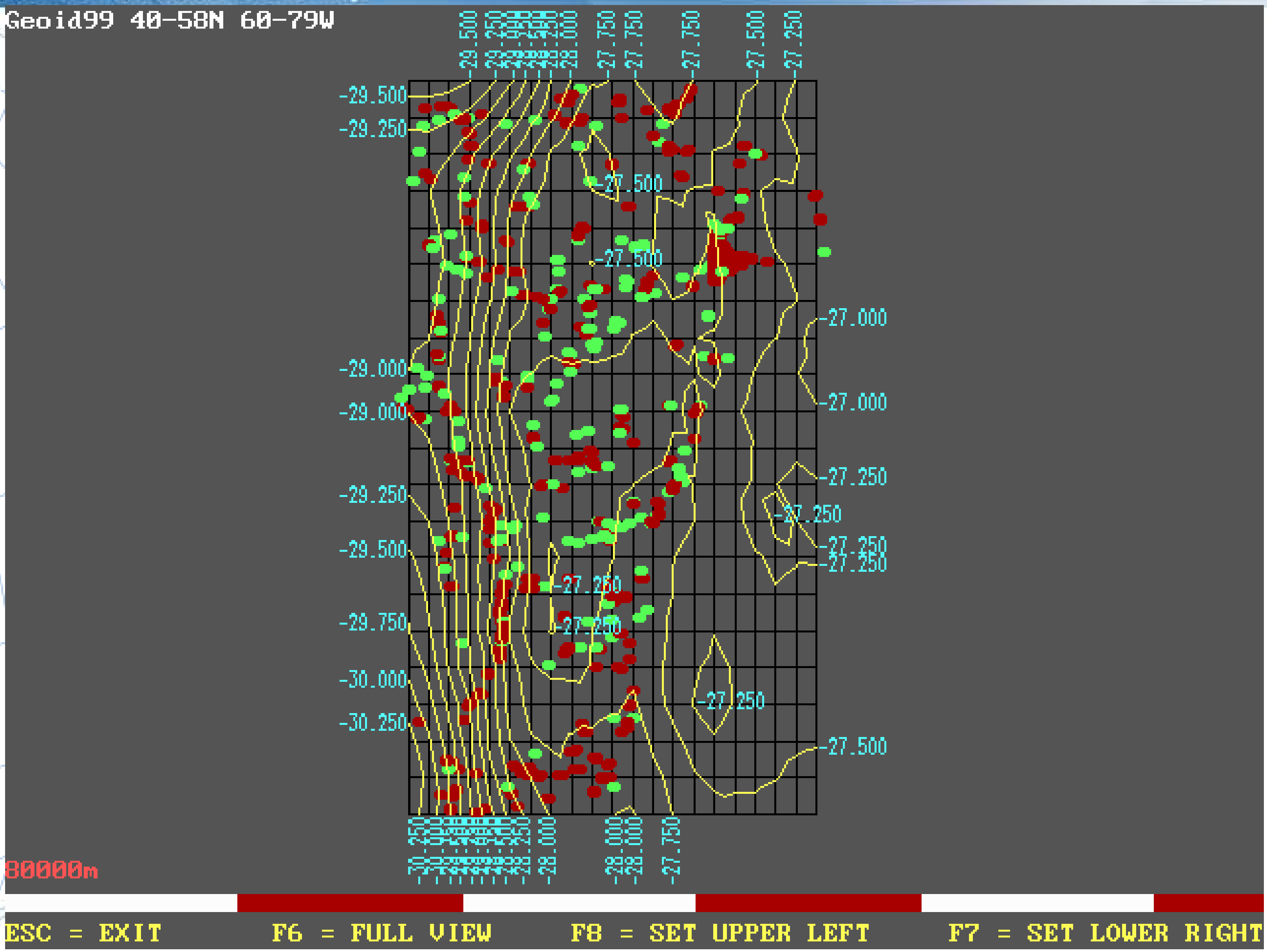
K_2=SF at point 2

K_m=SF at midpoint of line

$$S = D \times EF = D\left(\frac{R}{R+N+H}\right)$$



$$K_{12} = \frac{K_1 + 4K_m + K_2}{6}$$


Geoid99 40-58N 60-79W
80000m
ESC = EXIT
F6 = FULL VIEW
F8 = SET UPPER LEFT
F7 = SET LOWER RIGHT

Ellipsoid Reduction Factors for Vermont Average Geoid Height of -28.5m (-93.504ft)

Orthometric Height in Feet

	0-1000	1000-2000	2000-3000	3000-4000	4000-5000
0	1.00000447	0.99995664	0.99990881	0.99986099	0.99981317
100	0.99999969	0.99995186	0.99990403	0.99985621	0.99980839
200	0.99999491	0.99994708	0.99989925	0.99985143	0.99980361
300	0.99999012	0.99994229	0.99989447	0.99984665	0.99979883
400	0.99998534	0.99993751	0.99988969	0.99984186	0.99979405
500	0.99998056	0.99993273	0.99988490	0.99983708	0.99978927
600	0.99997577	0.99992794	0.99988012	0.99983230	0.99978449
700	0.99997099	0.99992316	0.99987534	0.99982752	0.99977971
800	0.99996621	0.99991838	0.99987056	0.99982274	0.99977492
900	0.99996142	0.99991360	0.99986577	0.99981796	0.99977014
1000	0.99995664	0.99990881	0.99986099	0.99981317	0.99976536

Grid Scale Factor at a point (k)

$$k = k_0 + \frac{E'^2}{2{r_0}^2}$$

K_0=Grid scale factor at central meridian (0.99996429)
r_0=Geometric mean radius of curvature scaled to the grid

**For VT, $\frac{1}{2{r_0}^2} \times 10^{14} = 1.22948$

E′ (also referred to as *X′*=(easting of point – false easting at central meridian) (E-E_0)

Grid Scale Factor for a line

$$K_{12} = \frac{K_1 + 4K_m + K_2}{6}$$

- Often approximated by computing average of K_1 and K_2
- Often acceptable to use one average Grid Scale Factor for a survey. Depends on size and east-west extents
- Often acceptable to use one average elevation factor in a survey. Depends on amount of relief.

Grid Scale Factors for VT (X’ in US Survey FT)

X’	Scale expressed as ratio	X’	Scale expressed as ratio
0	0.9999643	175,000	0.9999993
5,000	0.9999643	180,000	1.0000013
10,000	0.9999644	185,000	1.0000034
15,000	0.9999645	190,000	1.0000055
20,000	0.9999647	195,000	1.0000077
25,000	0.9999650	200,000	1.0000100
30,000	0.9999653	205,000	1.0000123
35,000	0.9999657	210,000	1.0000147
40,000	0.9999661	215,000	1.0000171
45,000	0.9999666	220,000	1.0000196
50,000	0.9999671	225,000	1.0000221
55,000	0.9999677	230,000	1.0000247
60,000	0.9999684	235,000	1.0000274
65,000	0.9999691	240,000	1.0000301
70,000	0.9999699	245,000	1.0000329
75,000	0.9999707	250,000	1.0000357
80,000	0.9999716	255,000	1.0000386
85,000	0.9999725	260,000	1.0000415
90,000	0.9999735	265,000	1.0000445
95,000	0.9999746	270,000	1.0000476
100,000	0.9999757	275,000	1.0000507
105,000	0.9999769	280,000	1.0000538
110,000	0.9999781	285,000	1.0000571
115,000	0.9999794	290,000	1.0000604
120,000	0.9999807	295,000	1.0000637
125,000	0.9999821	300,000	1.0000671
130,000	0.9999836	305,000	1.0000705
135,000	0.9999851	310,000	1.0000741
140,000	0.9999867	315,000	1.0000776
145,000	0.9999883	320,000	1.0000813
150,000	0.9999900	325,000	1.0000849
155,000	0.9999917	330,000	1.0000887
160,000	0.9999935	335,000	1.0000925
165,000	0.9999954	340,000	1.0000963
170,000	0.9999973	345,000	1.0001002
		350,000	1.0001042

Effect of SF and EF

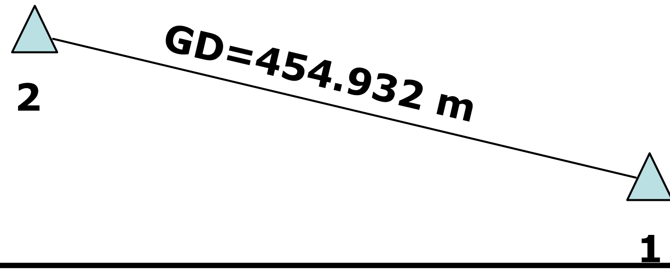
- 1000’ horizontal distance measured at the Central Meridian = 1000’*0.99996429 = 999.96’ (SF)
- 0.16 ppm per meter of geoid height
- Neglecting the geoid (-28.5 m) = -4.56 ppm
  - reduces distances by 4.56 mm (0.015’) per km
- If D=1000’ S=999.93 at ortho height of 1500’ (EF)
- If D=1000’ S=999.88 at ortho height of 2500’ (EF)
- If D=1000’ at the CM at ortho height of 1500’ then:
  - CF=Combined Factor = EF x GF

Distance on Grid=

1000*0.99996429*0.99993273=999.90

Two points with NAD 83 SPC. What is the horizontal distance between the two?

N=196070.049 m
E= 490343.673 m
H=166.3 m
N= -27.65 m



N=195854.310 m
E= 490744.197 m
H=161.0 m
N= -27.65 m

$$k = k_0 + \frac{E'^2}{2r_0^2}$$

$$k_1 = 0.99996429 + (490744.197 - 500000)^2 (1.22948 \times 10^{14})$$
$$= 0.999965343$$

$$k_2 = 0.99996429 + (490343.673 - 500000)^2 (1.22948 \times 10^{14})$$
$$= 0.999965436$$

$$k_m = 0.99996429 + \left(\frac{(490343.673 + 490744.197)}{2} - 500000\right)^2 (1.22948 \times 10^{14})$$
$$= 0.999965389$$

$$K_{12} = \frac{K_1 + 4K_m + K_2}{6} = 0.99996539$$

$$EF = \frac{R}{R + N + H}$$

$$\overline{H_{12}} = 163.65m$$

$$EF = \frac{6372000m}{6372000m + (-27.65) + 163.65m} = 0.99997866$$

$$GD = D \times EF \times GF$$

$$D = \frac{GD}{EF \times GF}$$

$$\boxed{D = \frac{454.932m}{0.99996539 \times 0.99997866} = 454.957m}$$

Which way is North

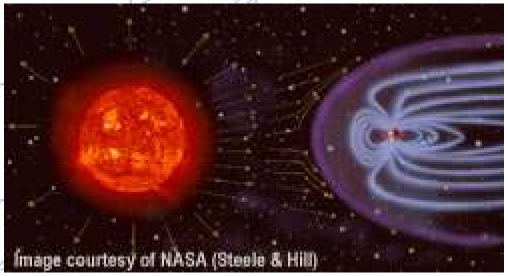
- True North
- Magnetic North
- Geodetic North
- Astronomic North
- Grid North

True North

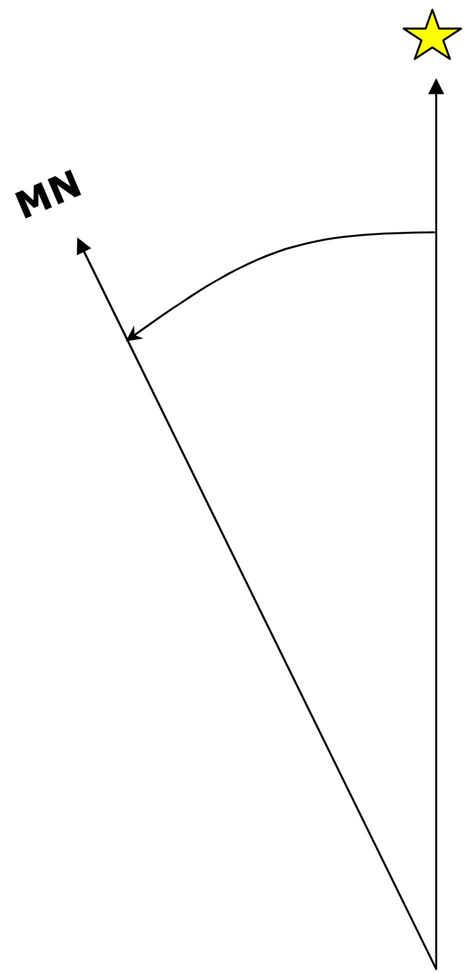
- True North – Really no such thing, but would be consistent with Geodetic North and would run along a meridian that passes through the geographic north pole

Magnetic North

- Magnetic North - The direction indicated by a magnetic compass. Magnetic North moves slowly with a variable rate, and points to the magnetic pole (+/- due to local attraction) not the geographic pole
- Users should be aware that solar storms can cause intense, short-term disturbances in the magnetic field. If there is a major solar storm during a survey, values could be off by as much as 10 degrees! A link to NOAA's Space Environment Center is provided for checking the current space weather forecast.



Magnetic Declination



Year	Declination	Year	Declination
1750	8° 38' W	1920	14° 46' W
1760	8° 5' W	1925	15° 10' W
1770	7° 41' W	1930	15° 28' W
1780	7° 24' W	1935	15° 40' W
1790	7° 19' W	1940	15° 43' W
1800	7° 26' W	1945	15° 44' W
1810	7° 41' W	1950	15° 36' W
1820	8° 8' W	1955	15° 33' W
1830	8° 42' W	1960	15° 34' W
1840	9° 24' W	1965	15° 31' W
1850	10° 7' W	1970	15° 29' W
1860	10° 51' W	1975	15° 32' W
1870	11° 27' W	1980	15° 41' W
1880	12° 7' W	1985	15° 37' W
1890	12° 31' W	1990	15° 43' W
1900	13° 4' W	1995	15° 50' W
1905	13° 30' W	2000	15° 42' W
1910	13° 59' W	2005	15° 23' W
1915	14° 27' W	2010	15° 0' W

Astronomic North

- Astronomic North – That which would be determined directly though astronomic observations.

- Expressed in a local horizon coordinate system aligned along the local gravity vector (line of the plumb bob). A geodetic azimuth, on the other hand is expressed about a local normal to the ellipsoid.

Laplace Correction = $\eta(\tan\phi)$

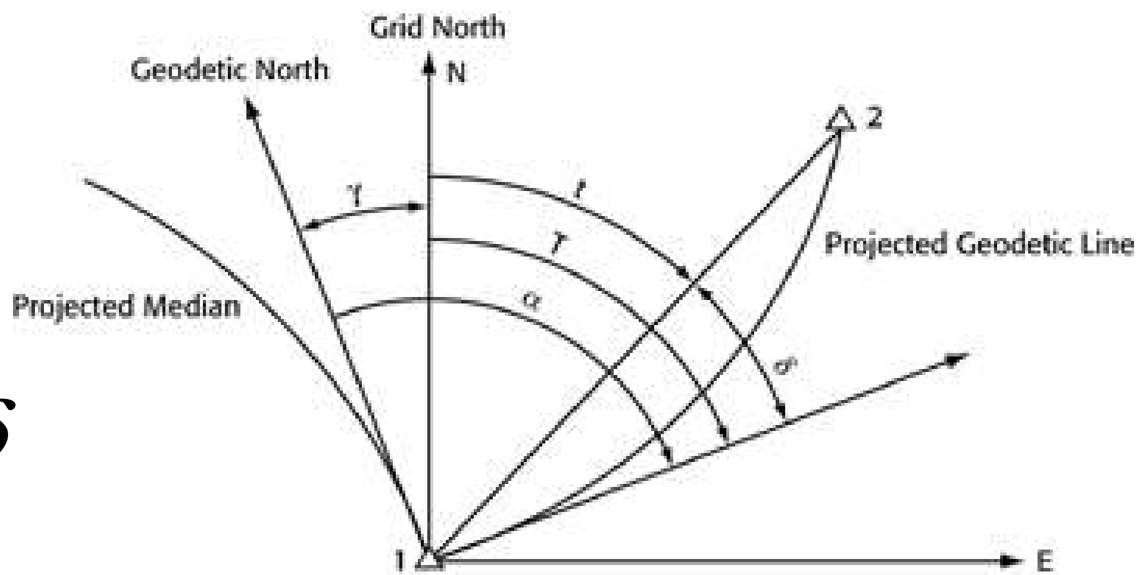
Where η =deflection of the vertical

Φ = Geodetic Latitude

Geodetic North and Grid North

- Geodetic North – Astronomic north corrected for the deflection of the vertical (Laplace correction)
- Grid North - The direction of a grid line which is parallel to the central meridian of a grid projection

Relation between Geodetic and Grid North



$$t = \alpha - \gamma + \delta$$

α = **geodetic azimuth reckoned from north**

T =projected geodetic azimuth

t =grid azimuth reckoned from north

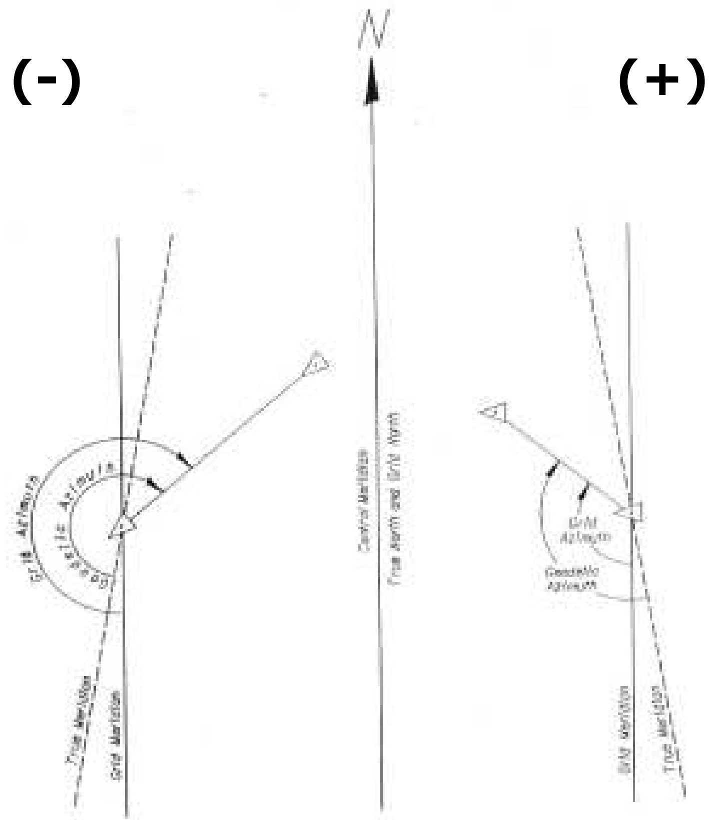
γ **=convergence angle**

δ **=t-T=second term correction=arc-to-chord correction**

Convergence Angle

$$\gamma'' = \left(\lambda''_{cm} - \lambda''\right)\sin\phi$$

(-) **(+)**



Angle/Azimuth Relationships

- Convergence Angle is NOT the difference between a geodetic az and a grid az. It IS the difference between a geodetic az and the projected geodetic az on the grid. The projected geodetic az is NOT the grid az.
- The angle obtained from two projected geodetic azimuths is a true representation of an observed angle.

$$t = \alpha - \gamma + \delta$$

- For many applications, δ may be insignificant, but should always be considered.

Arc to Chord Correction (t-T)

$$\delta_{12} = 25.4\underbrace{(N_2 - N_1)}_{\Delta N}\left(\underbrace{\frac{(E_2 - E_1)}{2} - E_0}_{\Delta E}\right)\times 10^{-10}$$

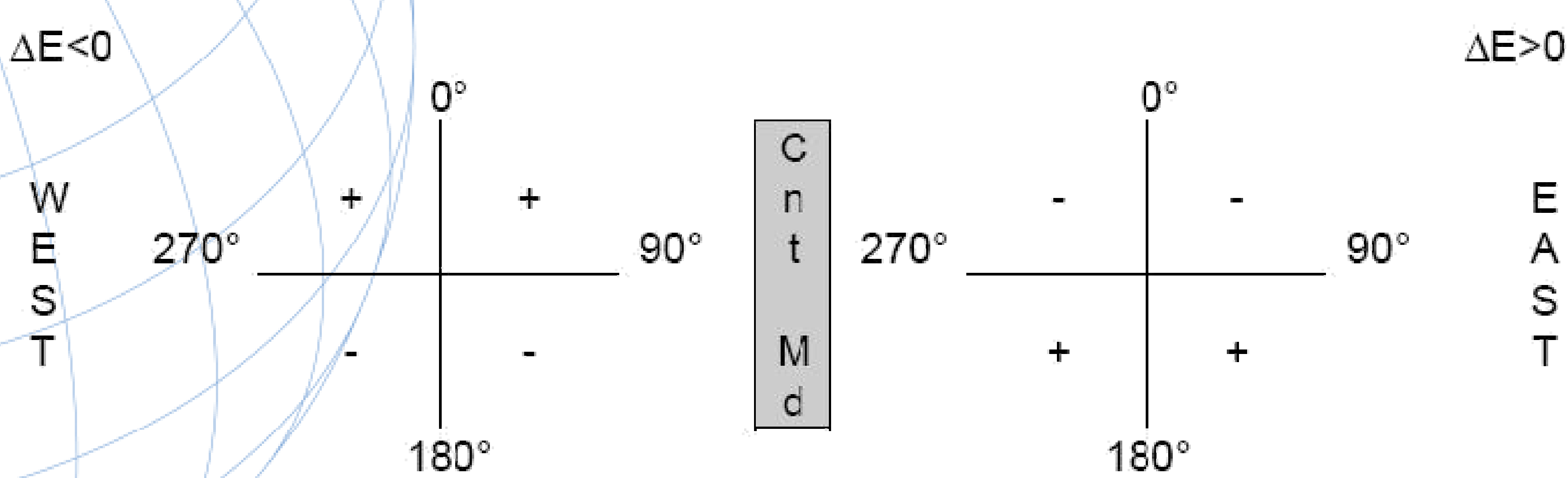
Where:

N_1, E_1, N_2, E_2 are the Northing and Easting of Points 1 and 2 respectively (in meters)

E_0 is the false Easting of the CM (in meters)

Sign of t-T Correction (for TM Projections)

Dependant on azimuth and location relative to central meridian



Approximate size of δ in seconds of arc

ΔN (km)	Perpendicular distance from central meridian to midpoint of the line (km)	
	50	100
2	0.3	0.5
5	0.6	1.3
10	1.3	2.5
20	2.5	5.1

Steps for computing a traverse

1. Obtain starting and closing azimuth
2. Analyze the grid scale factor for the project. A mean of the published point grid scale factors of the control points may be adequate for all lines in the project, or a grid scale factor for each line may be required.
3. Analyze the elevation factor for the project. A mean of the published elevations of the control points corrected for the geoid height may be adequate to compute the elevation factor. Otherwise each line may need to be reduced individually.

Traverse...cont

4. If a project grid scale factor and project elevation factor are applicable, compute a project combined factor.
5. Reduce the horizontal distances to grid
6. Using preliminary azimuths derived from unreduced angles and grid distances, compute approximate coordinates.
7. Analyze magnitude of (t-T) corrections, and if their application is required, compute (t-T) for each line using approximate coordinates for each point.
8. Apply (t-T) corrections to the measured angles to obtain grid angles. (Make sure to apply to FS and BS

Traverse...cont

9. Adjust Traverse
10. Compute the final adjusted State Plane Coordinates for the new points, adjusted azimuths and distances between the points, and if required, ground level distances.

Software

- CORPSCON
  - Error in computation of EF/CF. If computing in NAD 83 and using NAVD 88 or NGVD 29 heights, the program does not compute and use the ellipsoid height. If inputting GRS 80 ellipsoid heights then the computation is correct. Additionally, if user wants output in NAD 27 and selects GRS 80 as input heights, it computes the EF using the equations for NAD 83
- NGS Toolkit – Datum transformations and translations to and from geodetic coordinates and State Plane coordinates, Geoid Heights, Deflections of the Vertical
- Write your own – The equations can be easily developed in Excel or another spreadsheet software.

Ground Level Coordinates

"I WANT STATE PLANE COORDINATES RAISED TO GROUND LEVEL"

GROUND LEVEL COORDINATES ARE NOT STATE PLANE COORDINATES!!!!!!

Ground Level Coordinate Problems

- Rapid Distortions
- Projects Difficult to Tie Together
- Confusion of Coordinate Systems
- Lack of Documentation

Ground Level Coordinates "If You Do"

- Truncate Coordinate Values

N = 428,769.07 ft becomes 28,769.07

E = 1,650,223.15 ft becomes 50,223.15

And

DOCUMENT DOCUMENT DOCUMENT !!

Reference Material online at

www.ngs.noaa.gov/PUBS_LIB

- Article on the State Plane Coordinate (January 1937) -
- NOAA Manual NOS NGS 5 - State Plane Coordinate System of 1983 (January 1989)
- Understanding the State Plane Coordinate Systems (January 1977)
- The State Plane Coordinate Systems (A Manual for Surveyors) SP 235 (Revised 1977)

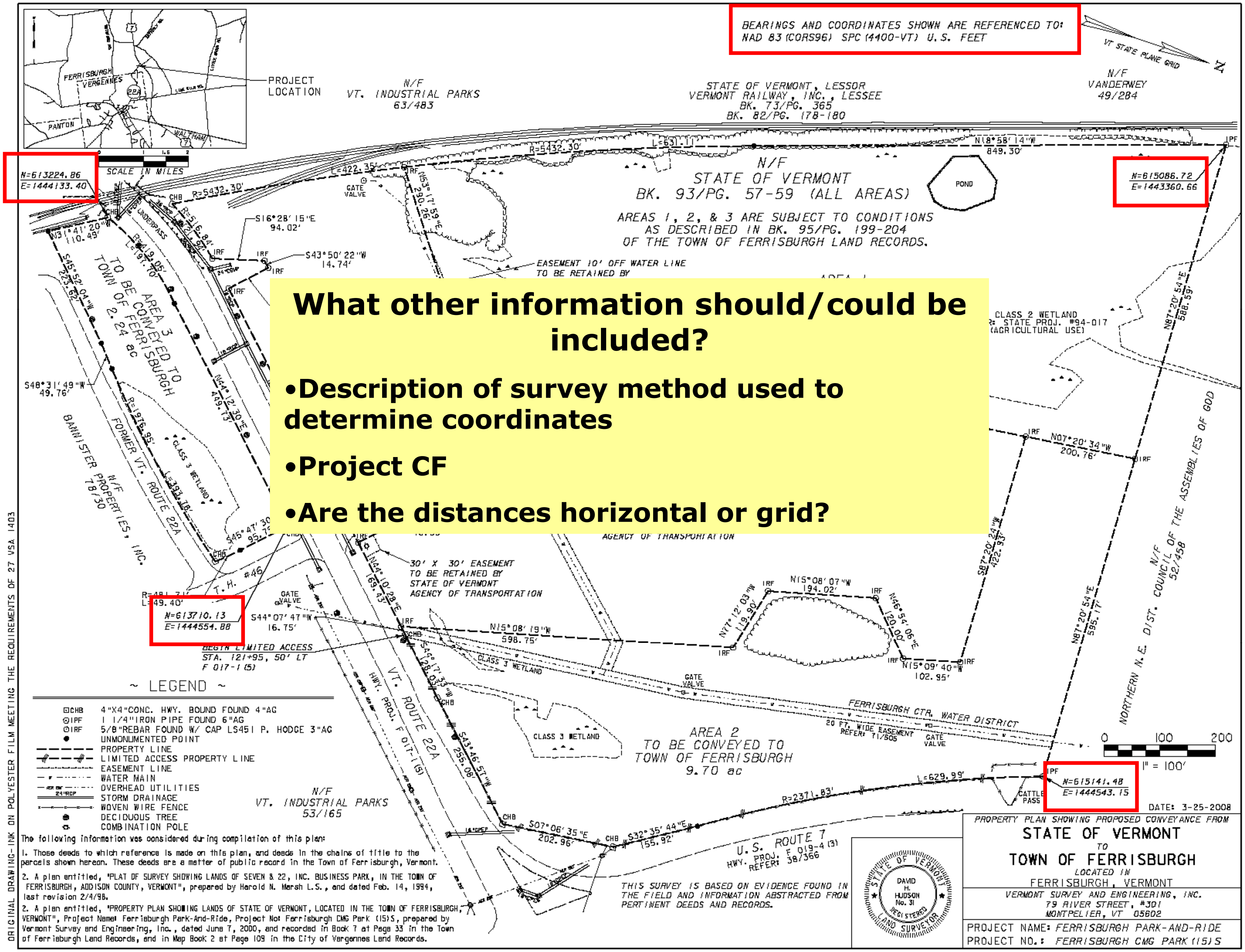
The Vermont Statutes Online

Title 1: General Provisions
Chapter 17: Vermont Coordinate System

674. Record

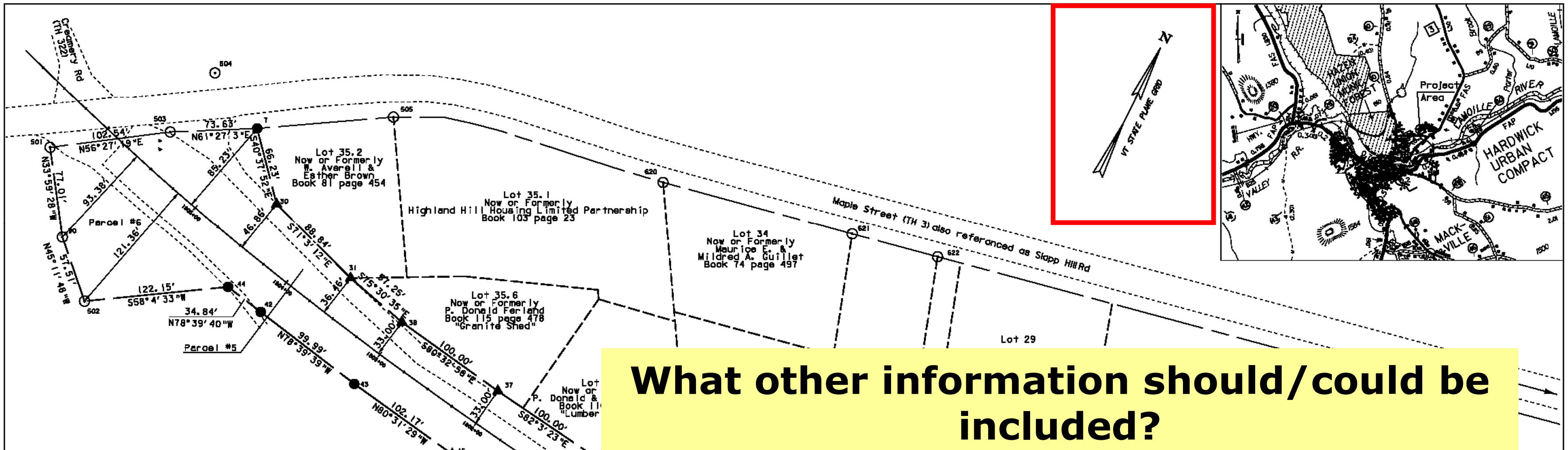
§ 674. Record

Coordinates based on either Vermont Coordinate System, purporting to define the position of a point on a land boundary, presented to be recorded in any public land records or deed records shall be accompanied by a specific statement as to their basis and a description of the survey method used to determine them on the record plat or description of the survey. (Amended 1987, No. 169 (Adj. Sess.), § 4, eff. May 3, 1988; 1993, No. 6, § 2.)



What other information should/could be included?

- **Description of survey method used to determine coordinates**
- **Project CF**
- **Are the distances horizontal or grid?**



What other information should/could be included?

- Description of survey method used to determine coordinates
- Project CF
- Are the distances horizontal or grid?
- Are the coordinates referenced to SPC?
- What are the coordinate units?

Reference:
* St Johnsbury & Lake Champlain R.R.Co. Railroad Valuation Sheet V50/35
* Parcels 4 & 6 are described in Volume 11 page 433 of the Hardwick Town Record, John Bridgman to Lamoille Valley Railroad (Sept. 25, 1834)
* Parcel 5 is described in Volume 18 page 8 of the Hardwick Town Records: R.G.Kimball to ST. Johnsbury & Lake Champlain Railroad Co. (Oct. 1, 1891)
* Original Lamoille Valley Rail-road survey records Volume 1, page 447-452
* Lot numbers refer to Town of Hardwick Tax Map sheet 24, and clerks counter listing detail dated 11-1-06

Notes:
* All Rights to existing Utilities are to be retained.
* All Bearings are based on the Vermont coordinate system NAD 83 (96)
* Boundaries based on physical evidence, previous surveys as referenced and record research.
* Railbanking and interim trail use of this railroad line under the National Trail System Act, 16 U.S.C. Section 1247(d) and 49 C.F.R. Section 1152.29, was authorized in Lamoille Valley R.R. Co. - Abandonment and Discontinuance of Trackage Rights Exemption - In Caledonia, Washington, Orleans, Lamoille, and Franklin Counties, VT, STB Docket No. AB-444 (Sub-No. 1X) (served Feb. 13, 2004) (notice of interim trail use).
* Lines shown on this plan as existing property lines are believed to be accurate but should not be relied upon for purposes unrelated to the State of Vermonts reestablishment of the Lamoille Valley RailRoad Right-of-Way.

Pins & Pipe Locations

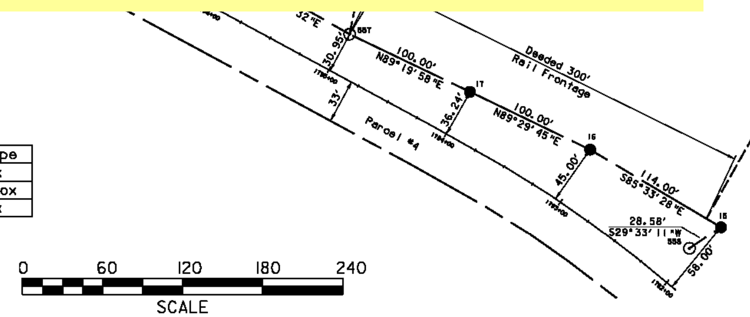
Point	Northing	Easting	Monument
7	730864.05	1676820.74	IP w/ Cap
15	730691.30	1678110.55	IP w/ Cap
16	730700.13	1677996.89	IP w/ Cap
17	730699.25	1677896.89	IP w/ Cap
18	730704.00	1677697.08	IP w/ Cap
19	730718.66	1677598.16	IP w/ Cap
20	730735.72	1677499.62	IP w/ Cap
34	730744.73	1677400.03	IP w/ Cap
42	730725.57	1676892.30	Spike
43	730705.91	1676990.34	IP w/ Cap
44	730732.42	1676858.14	Spike
90	730708.35	1676713.66	IP
501	730772.20	1676670.61	IP
502	730667.83	1676754.46	IP
503	730828.86	1676756.07	IPIPE
504	730890.47	1676767.90	IP*W/CAP RLS 73
505	730923.72	1676919.89	IP*W/CAP RLS 73
557	730698.09	1677796.89	IP
558	730666.44	1678096.45	IP
620	730974.91	1677149.10	IP
621	731006.33	1677312.10	IPIPE
622	731020.81	1677385.53	IPIPE

Angle Points

Point	Northing	Easting
30	730813.79	1676863.87
31	730784.95	1676947.89
35	730732.95	1677300.73
36	730740.38	1677201.00
37	730754.20	1677101.96
38	730770.62	1677003.32
45	730689.09	1677091.12
46	730675.01	1677191.88

Culverts from Val. Sheet V50/35

1794+72	18" Clay Pipe
1798+10	Stone Box
1800+44	Open Wood Box
1804+58	Stone Box



LEGEND:
- Iron Rod Set
- Iron Rod or Pipe Found
- Angle Point
- Road or Drive
- Approximate Property Line
- State Property Line

I hereby certify that this survey is based on field measurements, monumentation found and information referenced.

Paul R. Hodge, L.S.
Registered Land Surveyor

STATE OF VERMONT
AGENCY OF TRANSPORTATION

Lamoille Valley RailRoad
Right-of-Way Reestablishment
Hardwick

04x503 | DATE: 10-APR-2008 | DRAWN BY: R. Bullock

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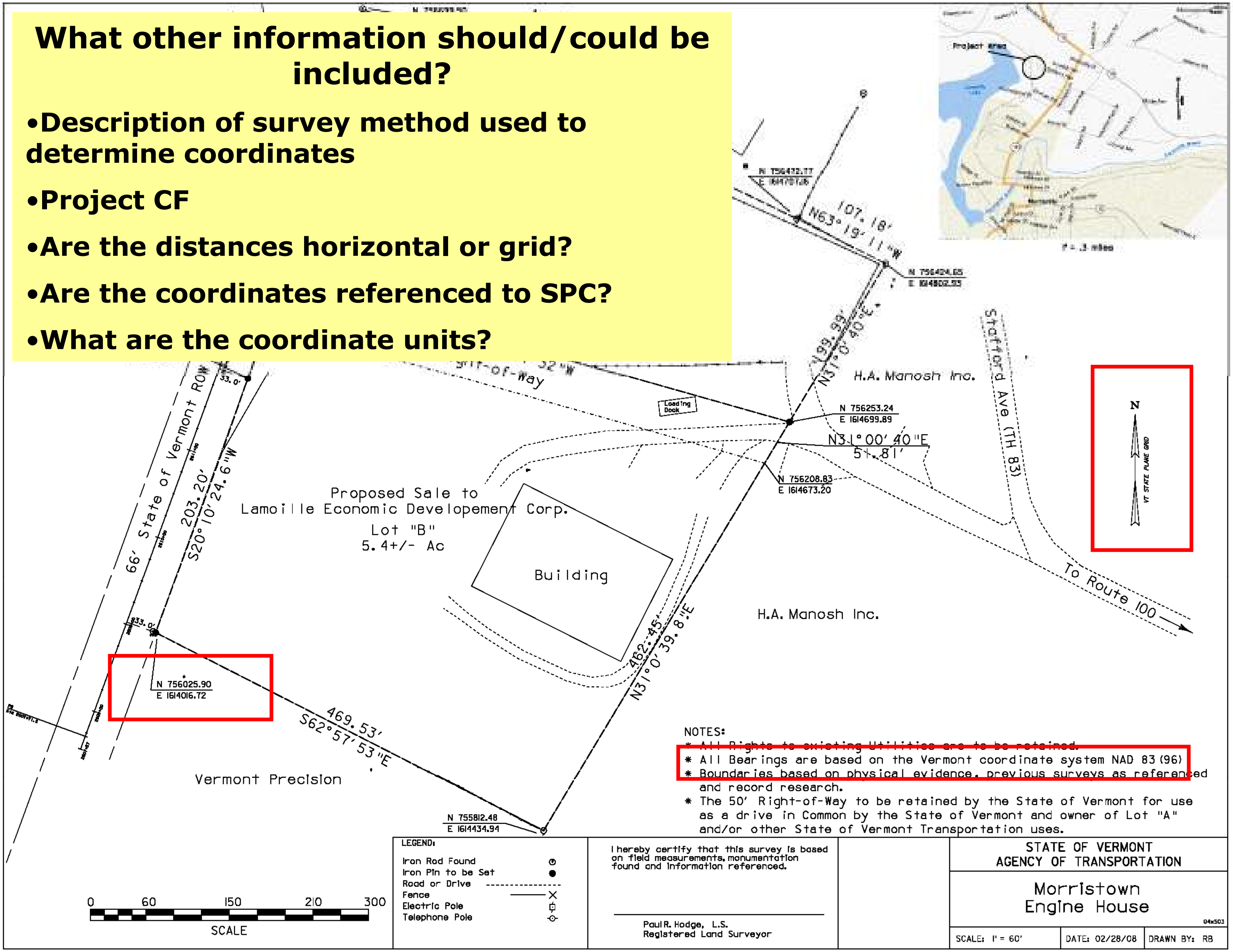

GOOD COORDINATION BEGINS WITH GOOD COORDINATES

GEOGRAPHY WITHOUT GEODESY IS A FELONY