Construction Engineers' Conference 2008

GPS and Related Topics

Construction Engineers' Conference 2008

Charlie Brown, PE, PLS
State Location &
Surveys Engineer

Construction Engineers' Conference 2008

What Do These Have In Common?

With GPS

Launch the Missile

Blow Up Your Construction Site

Construction Engi

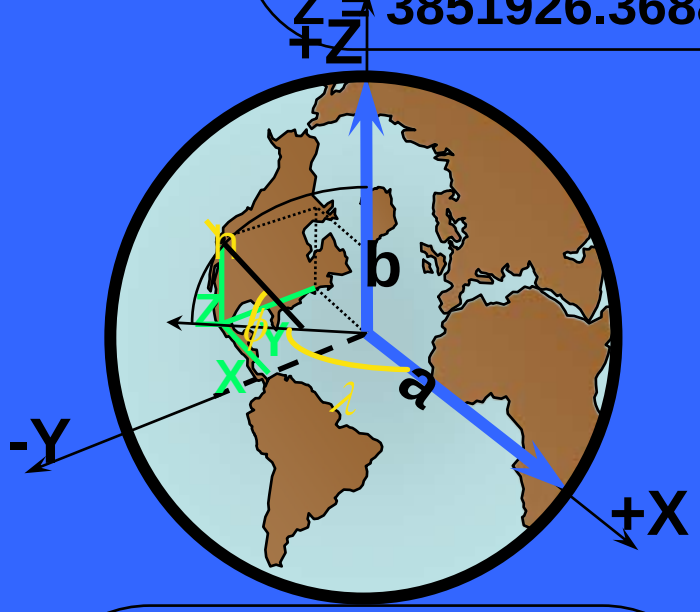
Or Guide Your Motor Grader

Terms

GNSS – Global Navigation Satellite System
Generic Term

GPS – United States
Glonass – Russia
Galileo – Europe
Compass – China

Cartesian system
X = -2691542.5437 m
Y = -4301026.4260 m
Z = 3851926.3688 m



Lat Lon
ϕ = 37° 23' 26.38035" N
λ = 122° 02' 16.62574" W
h = -5.4083 m

DATUM

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.

Horizontal Datums

North American Datum of 1983 (NAD 83)
High Accuracy Reference Network (HARN)
(2000, 2003, 2007 Adjustments)
North Carolina State Plane Coordinate System
Localized, either based on NCSPCS or Assumed
(allows for accurate ground distances)

Vertical Datums

NGVD 27
NAVD 88

Horizontal Datums

Shifts

NAD 27 – NAD 83 - 30' in NC

NAD 83 – HARN 2000 Adjustment ~3'

HARN 2003 Adjustment – 0.25'

HARN 2007 – 0.01'- 0.03'

Vertical Datums

NGVD 27 - NAVD 88 ~ 1' in NC

Why Use Datums?

Planning & Design

Access to data from other sources:
GIS – Wetlands, County Property, Utilities
Tie Projects Together

Construction

Build Adjacent Projects
Utilize Design Data

Maintenance

Asset Management
GIS Expansion

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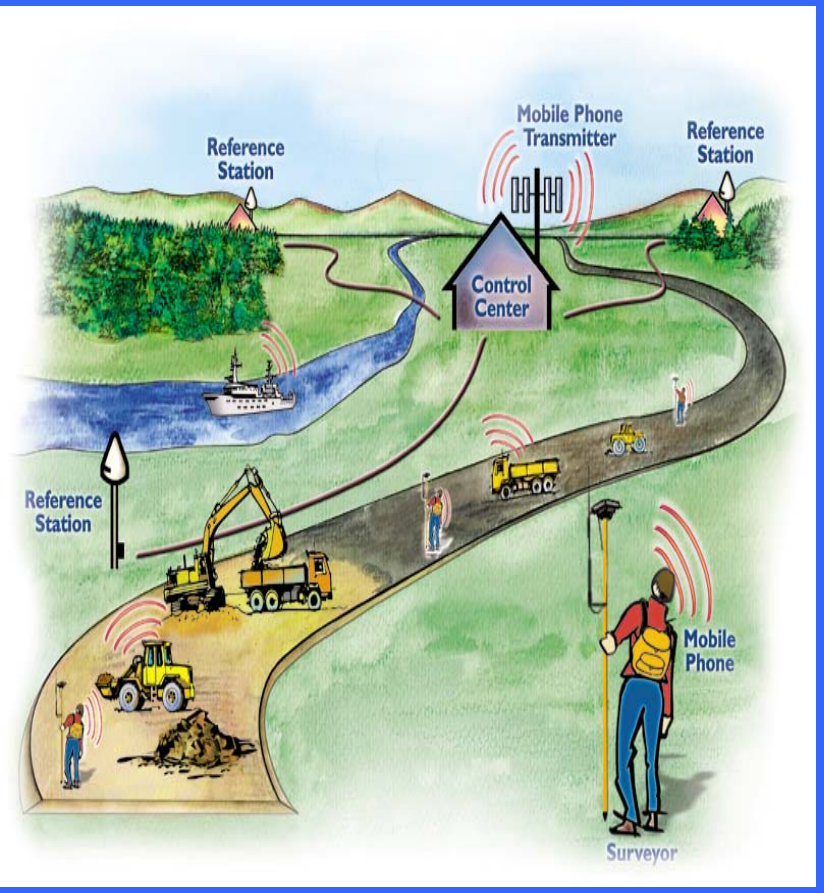
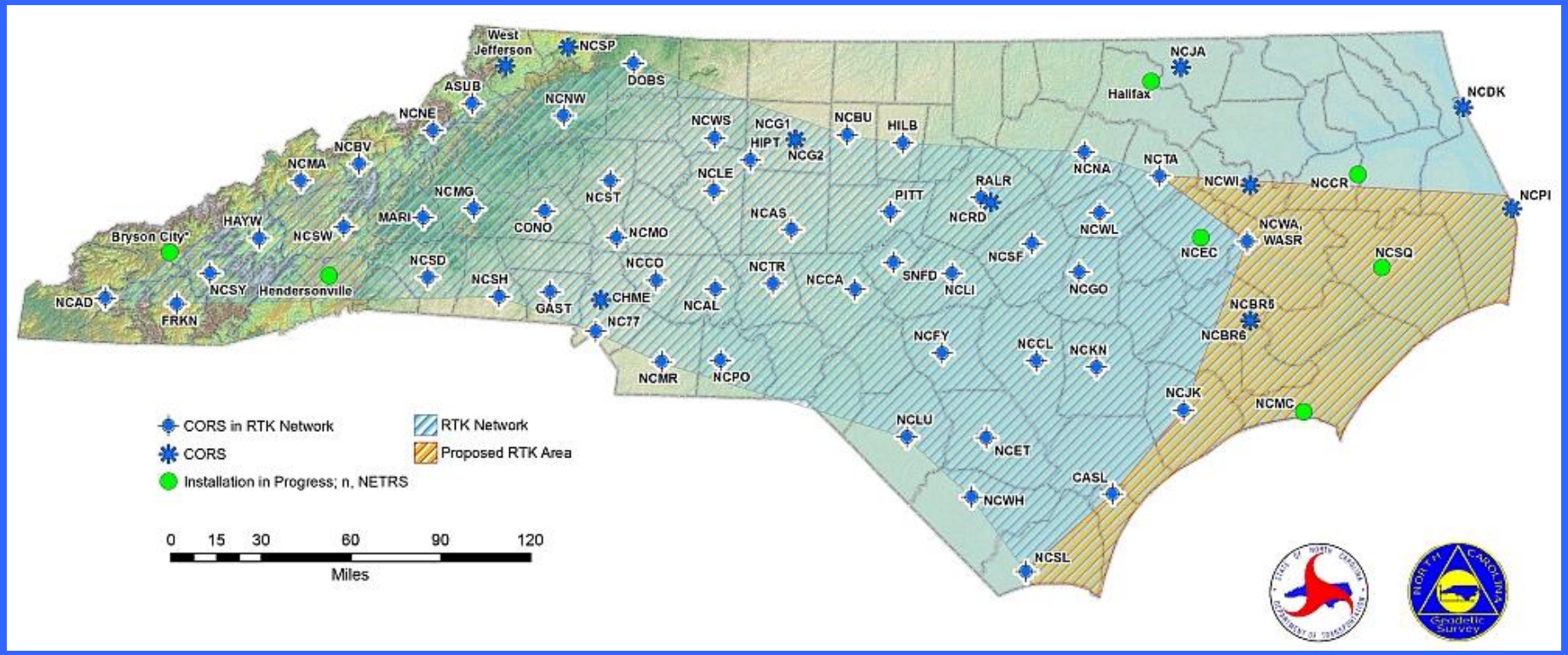
Different Datums-
Adjacent Projects

NC Network RTK (VRS)



- Virtual Reference System (Trimble)
- RTK Network Using Single or Multiple Base Stations
- More Accurate Correction Factor over Larger Area
- Transmits One Correction Factor to Multiple Rovers
- Utilizes Cell Phone Technology
- Stronger transmission signal for greater distance

NC Network RTK



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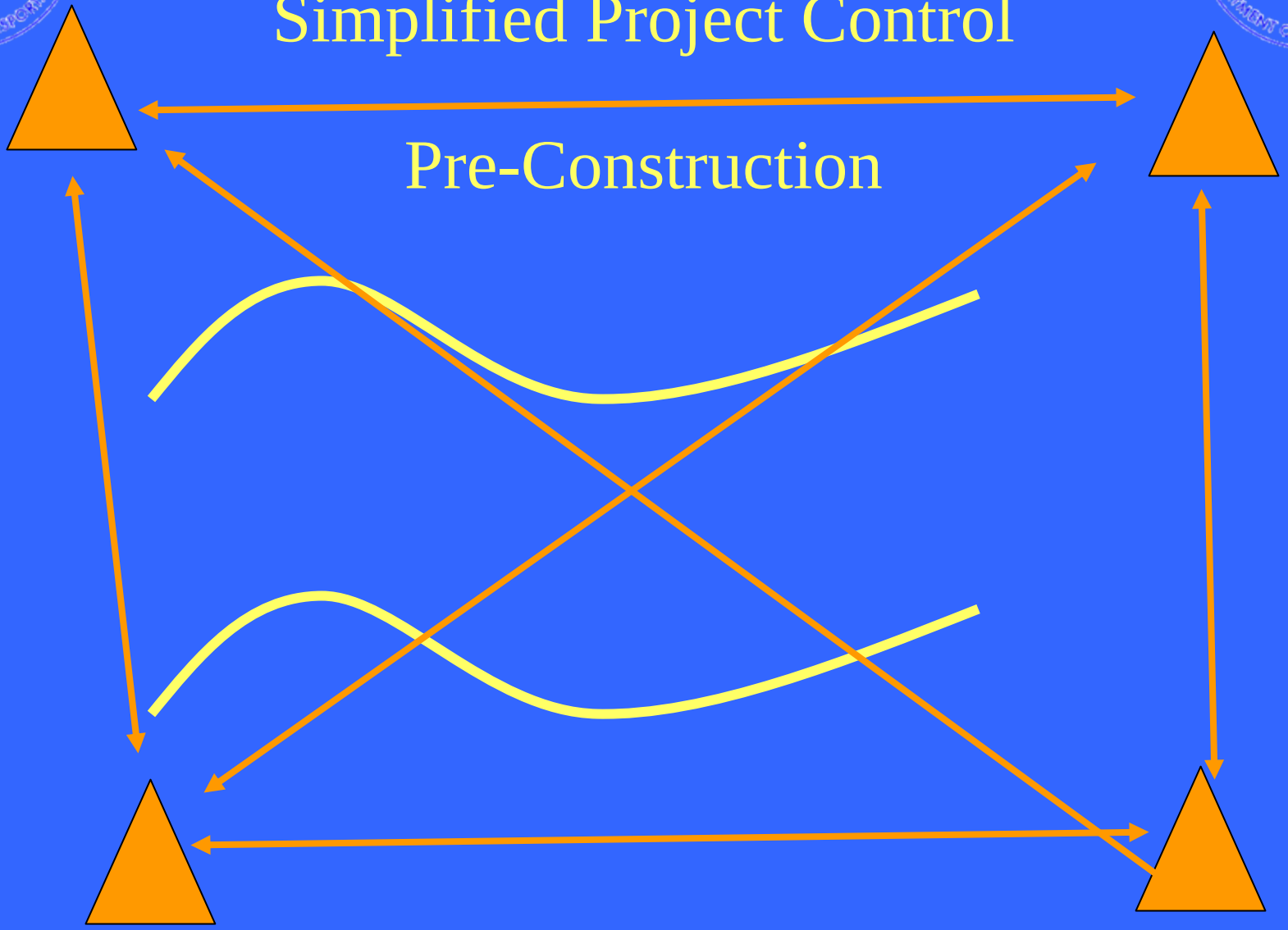
Simplified Project Control



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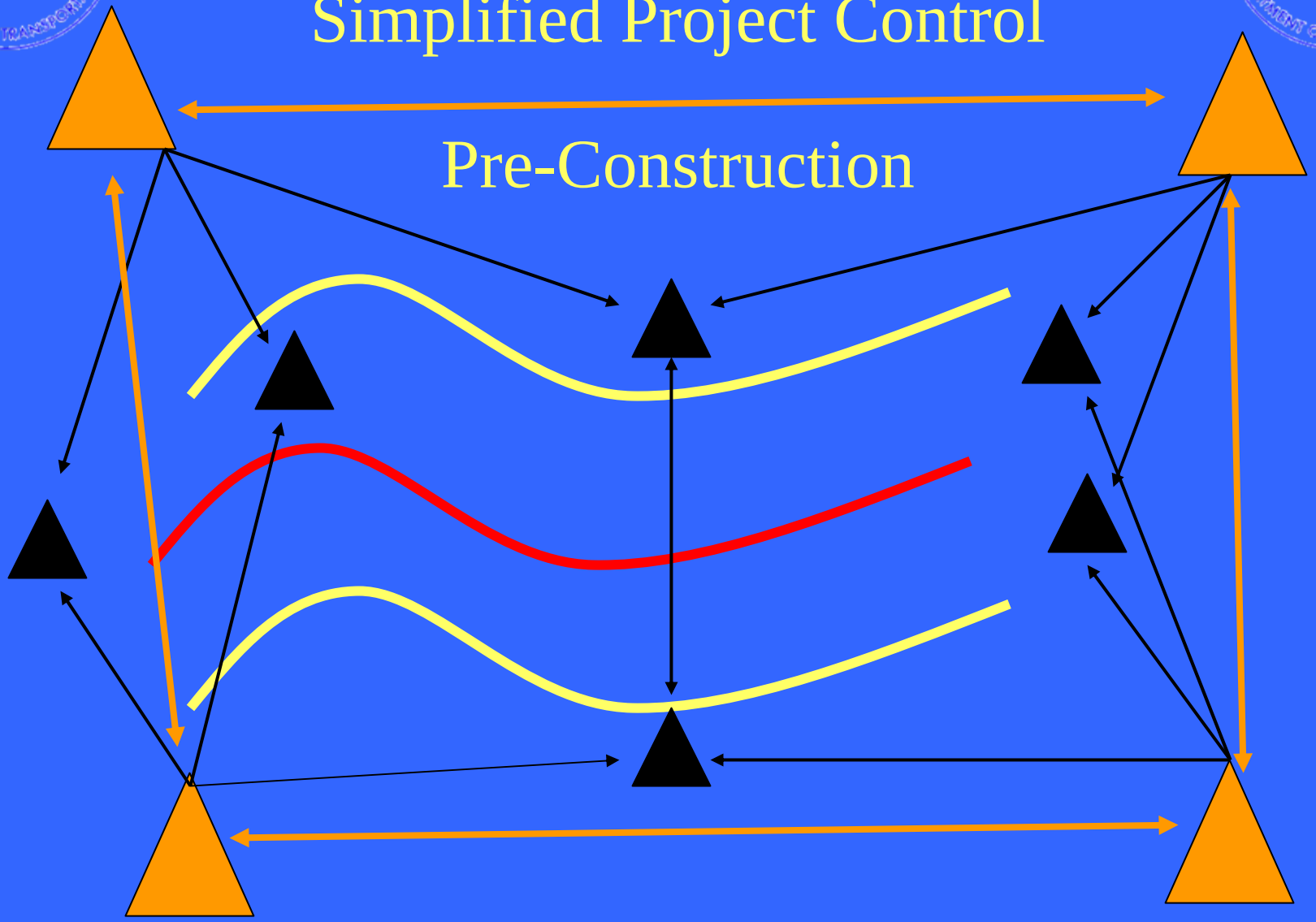
Simplified Project Control



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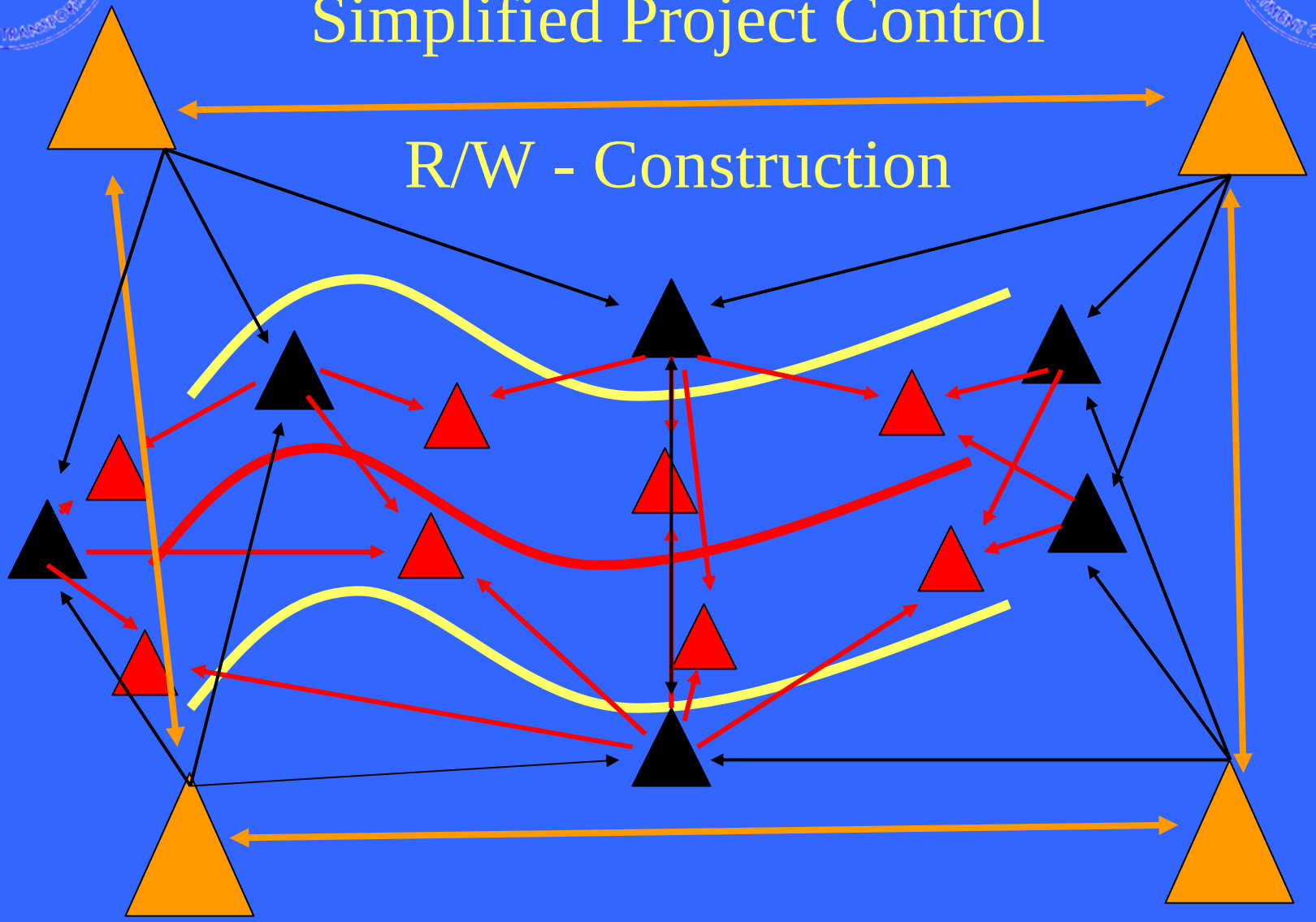
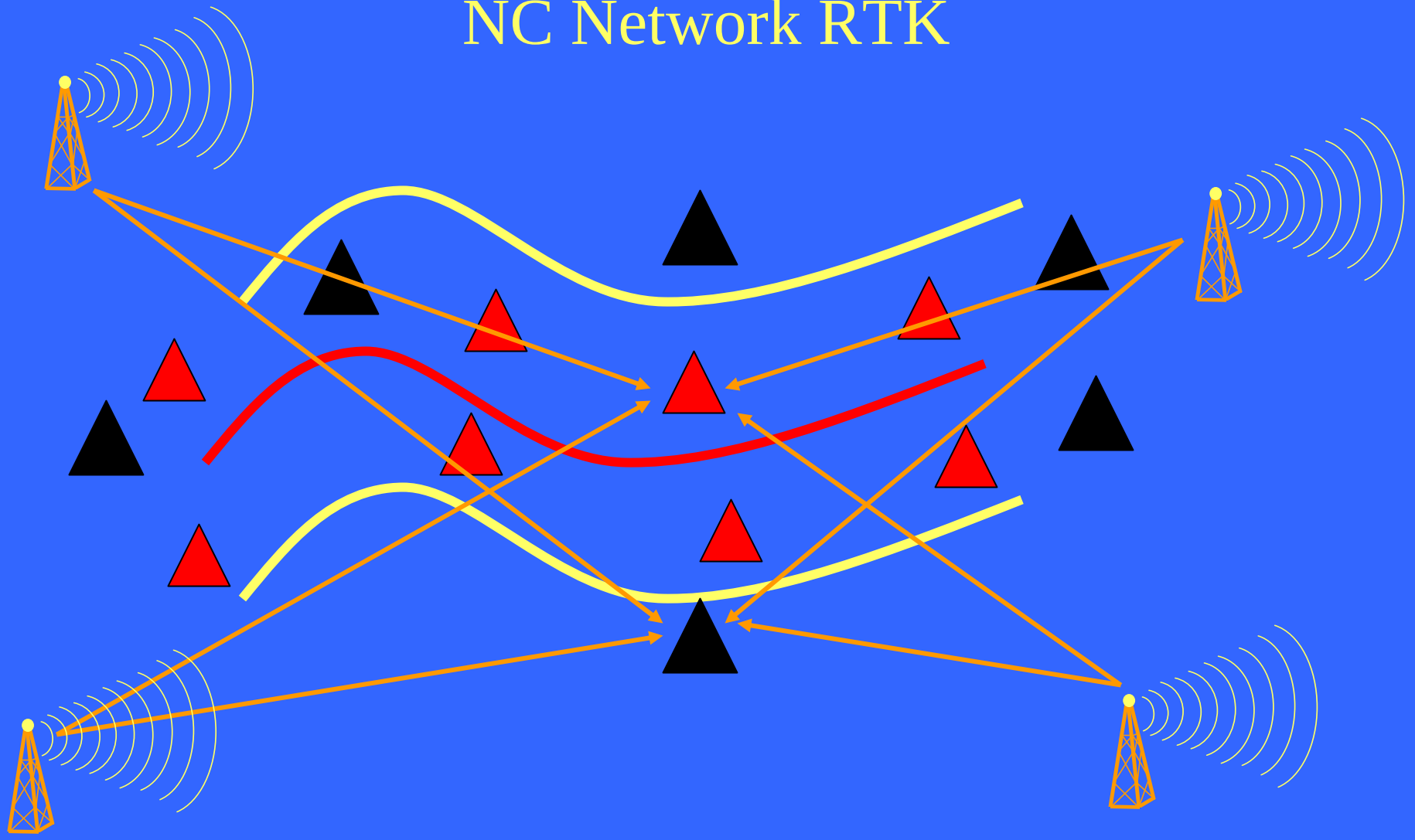
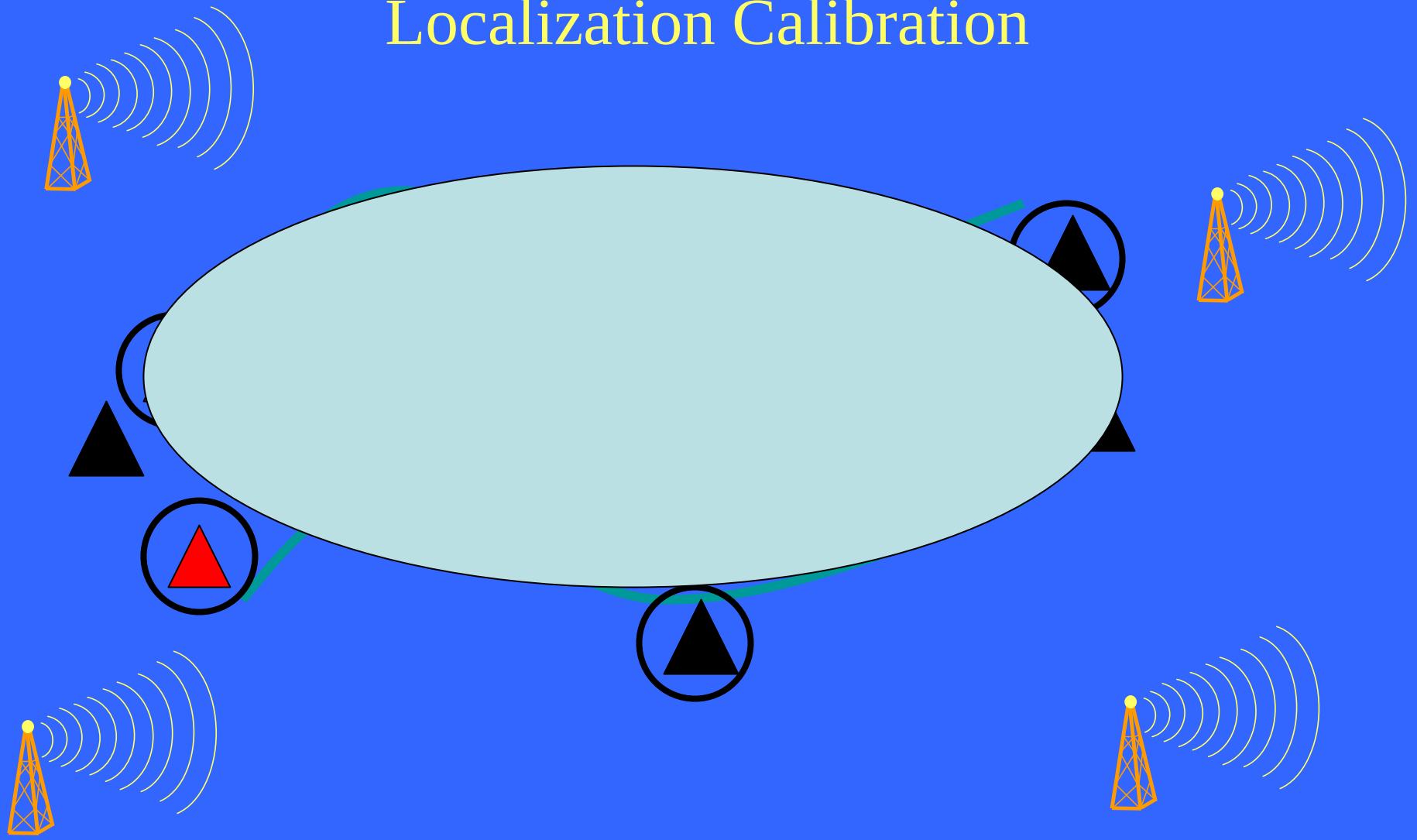
Simplified Project Control



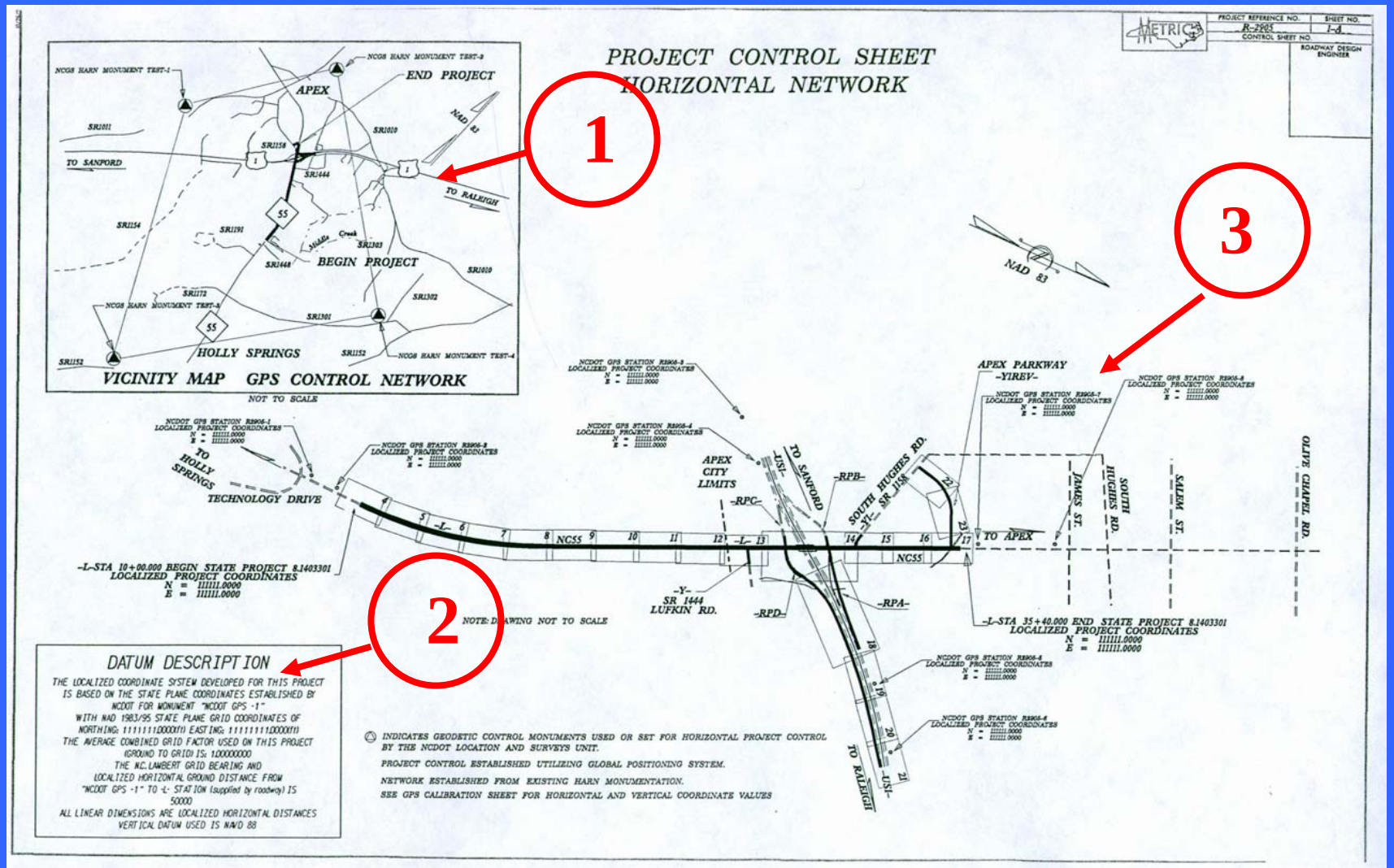
Simplified Project Control
NC Network RTK



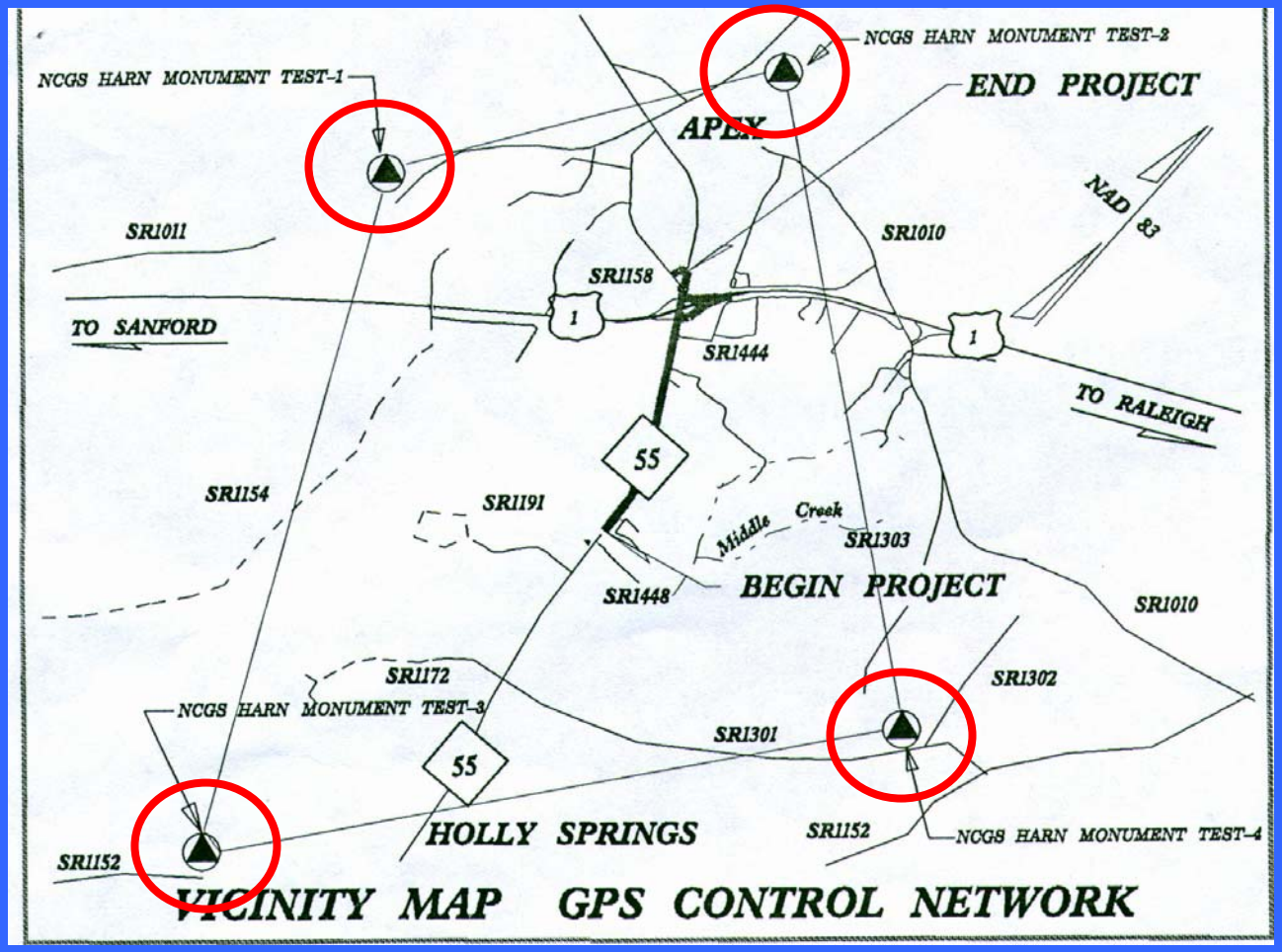
Simplified Project Control Localization Calibration



Project Horizontal Control Sheet



#1 HARN Monuments

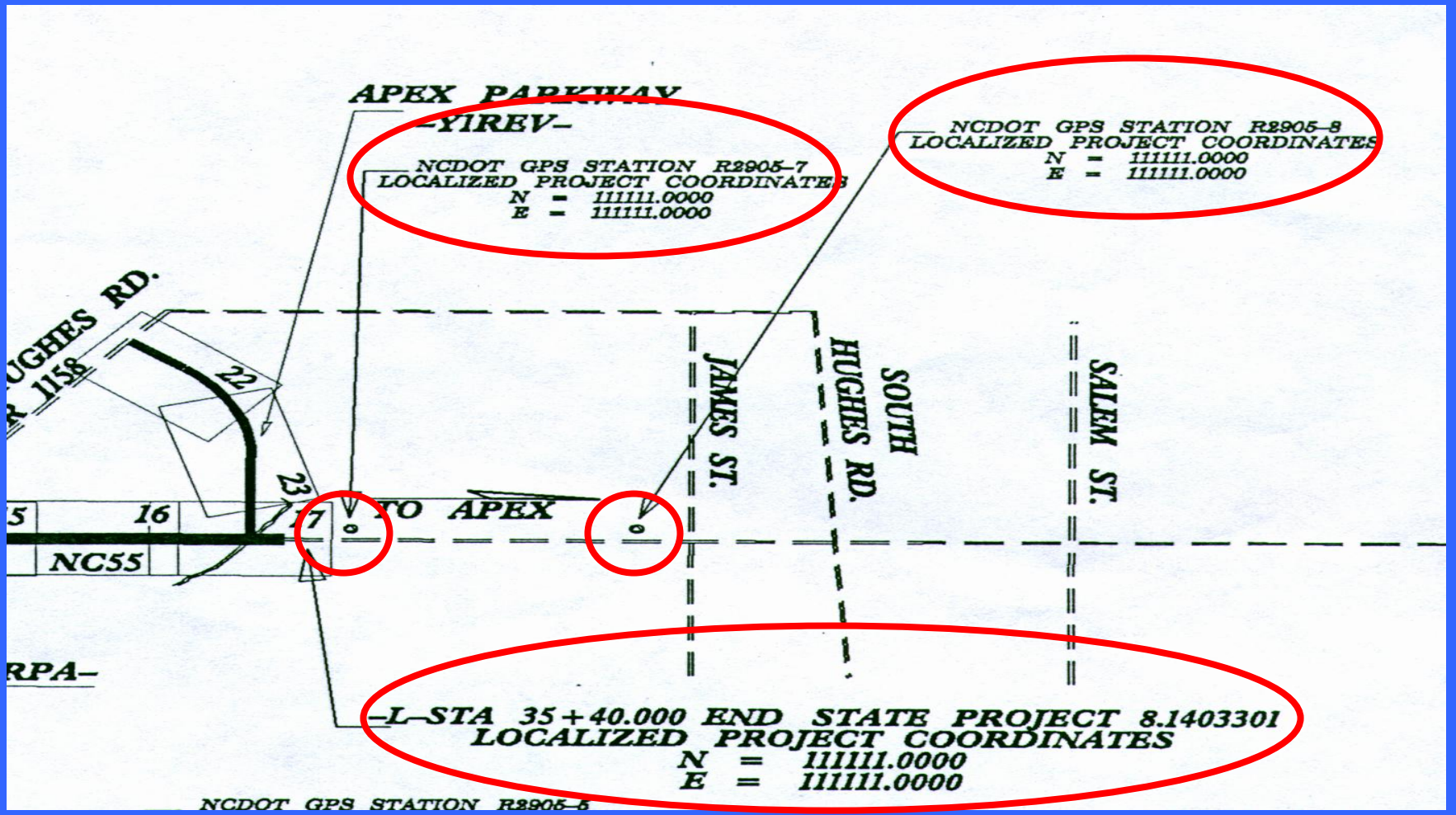


#2 Datum Description / Localization

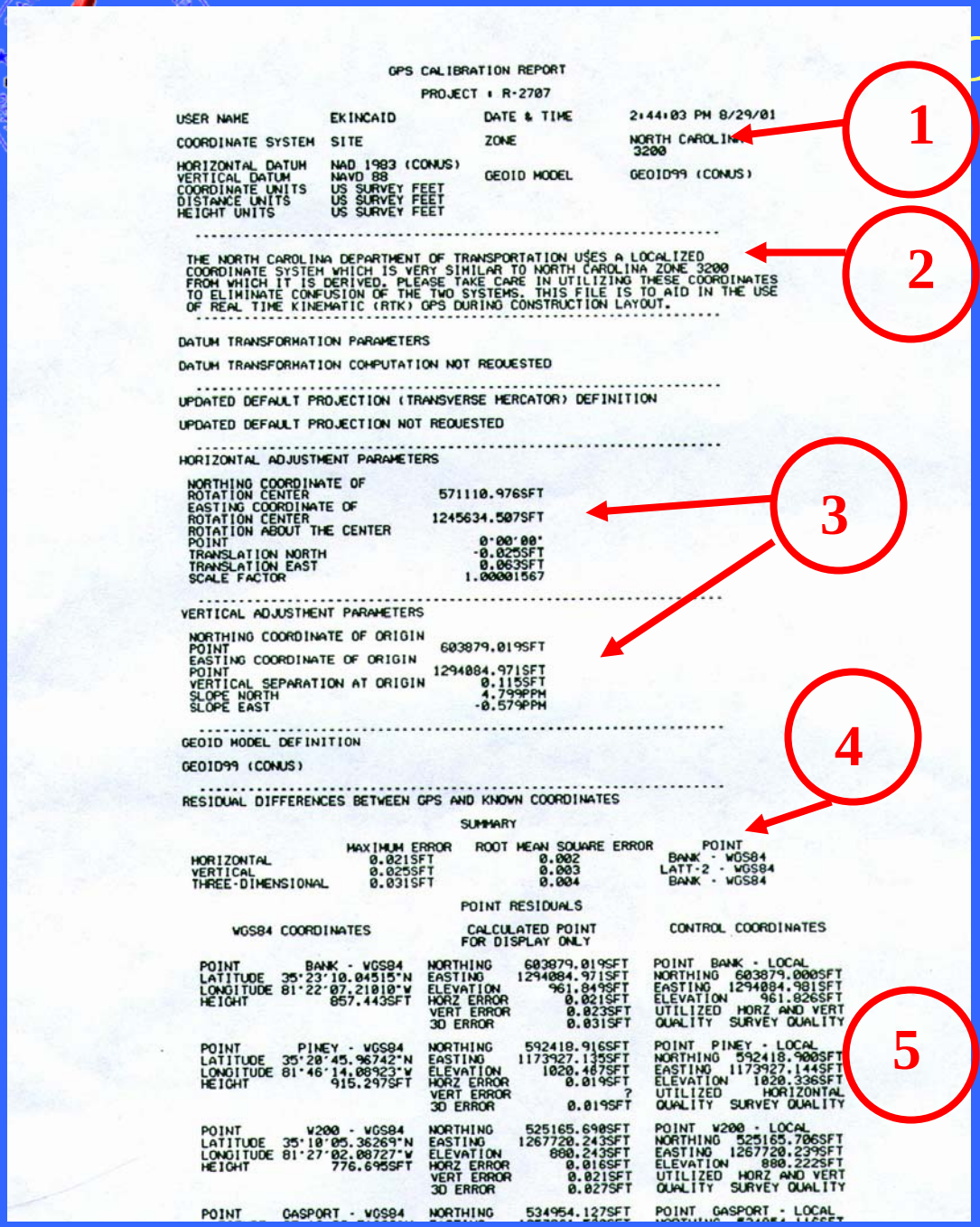
DATUM DESCRIPTION

THE LOCALIZED COORDINATE SYSTEM DEVELOPED FOR THIS PROJECT
IS BASED ON THE STATE PLANE COORDINATES ESTABLISHED BY
NCDOT FOR MONUMENT "NCDOT GPS -1"
WITH NAD 1983/95 STATE PLANE GRID COORDINATES OF
NORTHING: 1111111.0000(ft) EASTING: 11111111.0000(ft)
THE AVERAGE COMBINED GRID FACTOR USED ON THIS PROJECT
(GROUND TO GRID) IS: 1.00000000
THE N.C. LAMBERT GRID BEARING AND
LOCALIZED HORIZONTAL GROUND DISTANCE FROM
"NCDOT GPS -1" TO -L- STATION (supplied by roadway) IS
50000
ALL LINEAR DIMENSIONS ARE LOCALIZED HORIZONTAL DISTANCES
VERTICAL DATUM USED IS NAVD 88

#3 Project Control Points



GPS Calibration Information



GPS CALIBRATION REPORT

PROJECT : R-2707

USER NAME	EKINCAID	DATE & TIME	2:44:03 PM 8/29/01
COORDINATE SYSTEM	SITE	ZONE	NORTH CAROLINA 3200
HORIZONTAL DATUM	NAD 1983 (CONUS)	GEOID MODEL	GEOID99 (CONUS)
VERTICAL DATUM	NAVD 88		
COORDINATE UNITS	US SURVEY FEET		
DISTANCE UNITS	US SURVEY FEET		
HEIGHT UNITS	US SURVEY FEET		

THE NORTH CAROLINA DEPARTMENT OF TRANSPORTATION USES A LOCALIZED COORDINATE SYSTEM WHICH IS VERY SIMILAR TO NORTH CAROLINA ZONE 3200 FROM WHICH IT IS DERIVED. PLEASE TAKE CARE IN UTILIZING THESE COORDINATES TO ELIMINATE CONFUSION OF THE TWO SYSTEMS. THIS FILE IS TO AID IN THE USE OF REAL TIME KINEMATIC (RTK) GPS DURING CONSTRUCTION LAYOUT.

DATUM TRANSFORMATION PARAMETERS

DATUM TRANSFORMATION COMPUTATION NOT REQUESTED

UPDATED DEFAULT PROJECTION (TRANSVERSE MERCATOR) DEFINITION

UPDATED DEFAULT PROJECTION NOT REQUESTED

HORIZONTAL ADJUSTMENT PARAMETERS

NORTHING COORDINATE OF ROTATION CENTER	571110.976SFT
EASTING COORDINATE OF ROTATION CENTER	1245634.507SFT
ROTATION ABOUT THE CENTER POINT	0°00'00"
TRANSLATION NORTH	-0.025SFT
TRANSLATION EAST	0.063SFT
SCALE FACTOR	1.00001567

VERTICAL ADJUSTMENT PARAMETERS

NORTHING COORDINATE OF ORIGIN POINT	603879.019SFT
EASTING COORDINATE OF ORIGIN POINT	1294084.971SFT
VERTICAL SEPARATION AT ORIGIN	0.115SFT
SLOPE NORTH	4.799PPM
SLOPE EAST	-0.579PPM

GEOID MODEL DEFINITION

GEOID99 (CONUS)

RESIDUAL DIFFERENCES BETWEEN GPS AND KNOWN COORDINATES

SUMMARY

	MAXIMUM ERROR	ROOT MEAN SQUARE ERROR	POINT
HORIZONTAL	0.021SFT	0.002	BANK - WGS84
VERTICAL	0.025SFT	0.003	LATT-2 - WGS84
THREE-DIMENSIONAL	0.031SFT	0.004	BANK - WGS84

POINT RESIDUALS

WGS84 COORDINATES		CALCULATED POINT FOR DISPLAY ONLY		CONTROL COORDINATES	
POINT	BANK - WGS84	NORTHING	603879.019SFT	POINT	BANK - LOCAL
LATITUDE	35°23'10.04515"N	EASTING	1294084.971SFT	NORTHING	603879.000SFT
LONGITUDE	81°22'07.21010"W	ELEVATION	961.849SFT	EASTING	1294084.981SFT
HEIGHT	857.443SFT	HORZ ERROR	0.021SFT	ELEVATION	961.826SFT
		VERT ERROR	0.023SFT	UTILIZED	HORZ AND VERT
		3D ERROR	0.031SFT	QUALITY	SURVEY QUALITY
POINT	PINEY - WGS84	NORTHING	592418.916SFT	POINT	PINEY - LOCAL
LATITUDE	35°20'45.96742"N	EASTING	1173927.135SFT	NORTHING	592418.900SFT
LONGITUDE	81°46'14.08923"W	ELEVATION	1020.467SFT	EASTING	1173927.144SFT
HEIGHT	915.297SFT	HORZ ERROR	0.019SFT	ELEVATION	1020.336SFT
		VERT ERROR	?	UTILIZED	HORIZONTAL
		3D ERROR	0.019SFT	QUALITY	SURVEY QUALITY
POINT	W200 - WGS84	NORTHING	525165.690SFT	POINT	W200 - LOCAL
LATITUDE	35°10'05.36269"N	EASTING	1267720.243SFT	NORTHING	525165.706SFT
LONGITUDE	81°27'02.08727"W	ELEVATION	880.243SFT	EASTING	1267720.239SFT
HEIGHT	776.695SFT	HORZ ERROR	0.016SFT	ELEVATION	880.222SFT
		VERT ERROR	0.021SFT	UTILIZED	HORZ AND VERT
		3D ERROR	0.027SFT	QUALITY	SURVEY QUALITY
POINT	GASPORT - WGS84	NORTHING	534954.127SFT	POINT	GASPORT - LOCAL

1
2
3
4
5

GPS CALIBRATION REPORT

PROJECT : R-2707

USER NAME	EKINCAID	DATE & TIME	2:44:03 PM 8/29/01
COORDINATE SYSTEM	SITE	ZONE	NORTH CAROLINA 3200
HORIZONTAL DATUM	NAD 1983 (CONUS)		
VERTICAL DATUM	NAVD 88	GEOID MODEL	GEOID99 (CONUS)
COORDINATE UNITS	US SURVEY FEET		
DISTANCE UNITS	US SURVEY FEET		
HEIGHT UNITS	US SURVEY FEET		

THE NORTH CAROLINA DEPARTMENT OF TRANSPORTATION USES A LOCALIZED COORDINATE SYSTEM WHICH IS VERY SIMILAR TO NORTH CAROLINA ZONE 3200 FROM WHICH IT IS DERIVED. PLEASE TAKE CARE IN UTILIZING THESE COORDINATES TO ELIMINATE CONFUSION OF THE TWO SYSTEMS. THIS FILE IS TO AID IN THE USE OF REAL TIME KINEMATIC (RTK) GPS DURING CONSTRUCTION LAYOUT.

DATUM TRANSFORMATION PARAMETERS

DATUM TRANSFORMATION COMPUTATION NOT REQUESTED

UPDATED DEFAULT PROJECTION (TRANSVERSE MERCATOR) DEFINITION

UPDATED DEFAULT PROJECTION NOT REQUESTED

HORIZONTAL ADJUSTMENT PARAMETERS

NORTHING COORDINATE OF ROTATION CENTER	571110.976SFT
EASTING COORDINATE OF ROTATION CENTER	1245634.507SFT
ROTATION ABOUT THE CENTER POINT	0°00'00"
TRANSLATION NORTH	-0.025SFT
TRANSLATION EAST	0.063SFT
SCALE FACTOR	1.00001567

VERTICAL ADJUSTMENT PARAMETERS

NORTHING COORDINATE OF ORIGIN POINT	603879.019SFT
EASTING COORDINATE OF ORIGIN POINT	1294084.971SFT
VERTICAL SEPARATION AT ORIGIN	0.115SFT
SLOPE NORTH	4.799PPM
SLOPE EAST	-0.579PPM

GEOID MODEL DEFINITION

GEOID99 (CONUS)

1

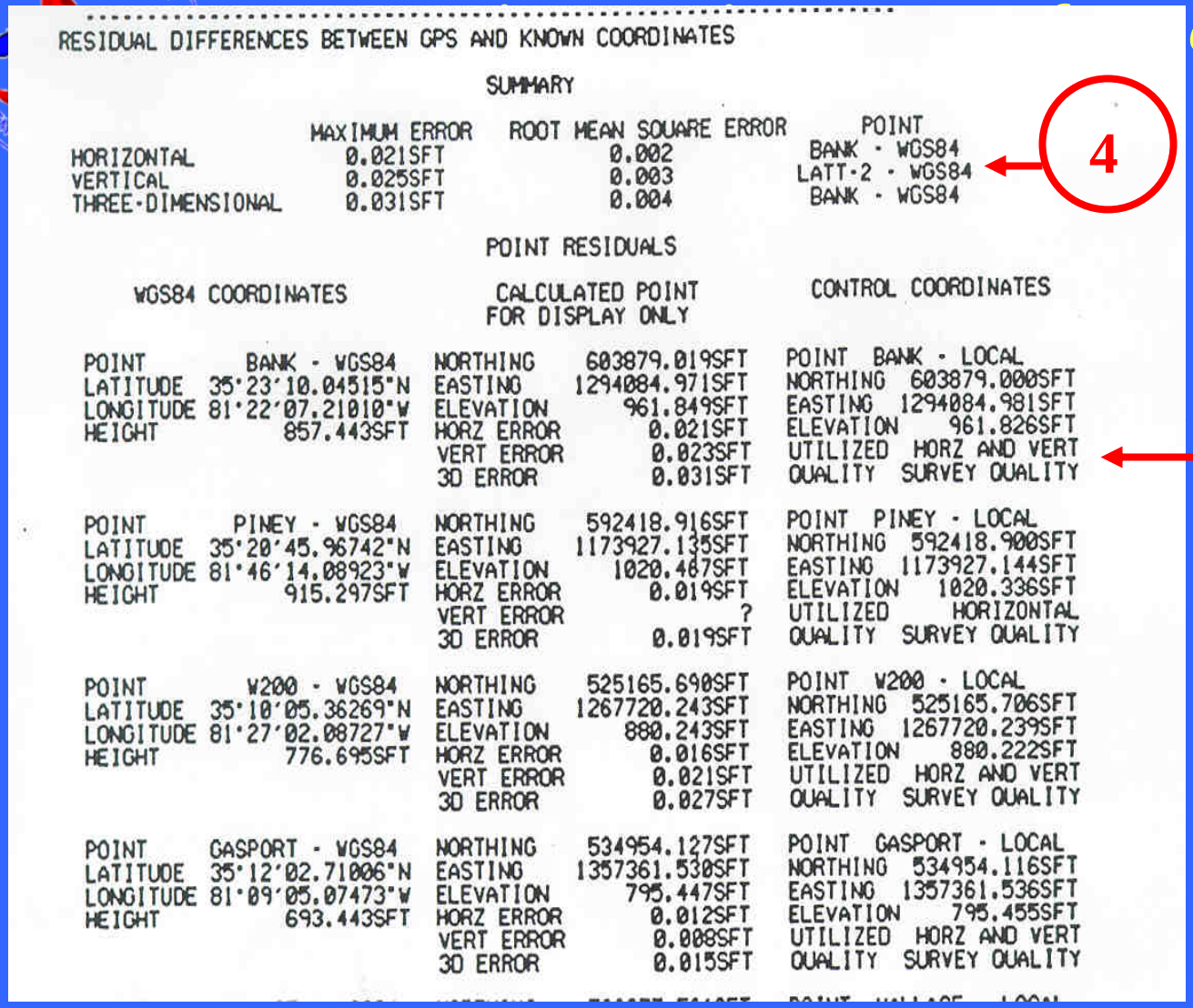
Horizontal & Vertical Data, Units of Measure

2

Warning - Localized Coordinates

3

Horizontal & Vertical Adjustment Data



RESIDUAL DIFFERENCES BETWEEN GPS AND KNOWN COORDINATES

SUMMARY

	MAXIMUM ERROR	ROOT MEAN SQUARE ERROR	POINT
HORIZONTAL	0.021SFT	0.002	BANK - WGS84
VERTICAL	0.025SFT	0.003	LATT-2 - WGS84
THREE-DIMENSIONAL	0.031SFT	0.004	BANK - WGS84

POINT RESIDUALS

WGS84 COORDINATES		CALCULATED POINT FOR DISPLAY ONLY		CONTROL COORDINATES	
POINT	BANK - WGS84	NORTHING	603879.019SFT	POINT	BANK - LOCAL
LATITUDE	35°23'10.04515"N	EASTING	1294084.971SFT	NORTHING	603879.000SFT
LONGITUDE	81°22'07.21010"W	ELEVATION	961.849SFT	EASTING	1294084.981SFT
HEIGHT	857.443SFT	HORZ ERROR	0.021SFT	ELEVATION	961.826SFT
		VERT ERROR	0.023SFT	UTILIZED	HORZ AND VERT
		3D ERROR	0.031SFT	QUALITY	SURVEY QUALITY
POINT	PINEY - WGS84	NORTHING	592418.916SFT	POINT	PINEY - LOCAL
LATITUDE	35°20'45.96742"N	EASTING	1173927.135SFT	NORTHING	592418.900SFT
LONGITUDE	81°46'14.08923"W	ELEVATION	1020.487SFT	EASTING	1173927.144SFT
HEIGHT	915.297SFT	HORZ ERROR	0.019SFT	ELEVATION	1020.336SFT
		VERT ERROR	?	UTILIZED	HORIZONTAL
		3D ERROR	0.019SFT	QUALITY	SURVEY QUALITY
POINT	W200 - WGS84	NORTHING	525165.690SFT	POINT	W200 - LOCAL
LATITUDE	35°10'05.36269"N	EASTING	1267720.243SFT	NORTHING	525165.706SFT
LONGITUDE	81°27'02.08727"W	ELEVATION	880.243SFT	EASTING	1267720.239SFT
HEIGHT	776.695SFT	HORZ ERROR	0.016SFT	ELEVATION	880.222SFT
		VERT ERROR	0.021SFT	UTILIZED	HORZ AND VERT
		3D ERROR	0.027SFT	QUALITY	SURVEY QUALITY
POINT	GASPORT - WGS84	NORTHING	534954.127SFT	POINT	GASPORT - LOCAL
LATITUDE	35°12'02.71006"N	EASTING	1357361.530SFT	NORTHING	534954.116SFT
LONGITUDE	81°09'05.07473"W	ELEVATION	795.447SFT	EASTING	1357361.536SFT
HEIGHT	693.443SFT	HORZ ERROR	0.012SFT	ELEVATION	795.455SFT
		VERT ERROR	0.008SFT	UTILIZED	HORZ AND VERT
		3D ERROR	0.015SFT	QUALITY	SURVEY QUALITY

ce 2008

Adjustment Summary & Error

4

5

- **Point Number**
- **Lat/Long/Elev**
- **Calculated Coordinates**
- **Control Coordinates**

Text File: Path and File Name

Http://www...

Conference 2008

PROJECT CONTROL SHEET PROJECT R-2552AB

DATUM DESCRIPTION

THE LOCALIZED COORDINATE SYSTEM DEVELOPED FOR THIS PROJECT
IS BASED ON THE STATE PLANE COORDINATES ESTABLISHED BY
NCGS FOR MONUMENT "LAKE DAM"
WITH NAD 83 STATE PLANE GRID COORDINATES OF
NORTHING: 222085.5690(m) EASTING: 636096.3610(m)
THE AVERAGE COMBINED GRID FACTOR USED ON THIS PROJECT
(GROUND TO GRID) IS: 0.999895575
THE N.C. LAMBERT GRID BEARING
LOCALIZED HORIZONTAL GROUND DISTANCE FROM
"LAKE DAM" TO -L- STATION (supplied by roadway) IS

ALL LINEAR DIMENSIONS ARE LOCALIZED HORIZONTAL DISTANCES
VERTICAL DATUM USED IS NGVD 29

* LINE BL

POINT	NORTH	EAST	STATION	ELEVATION
21	208,585.2620	652,727.2850	45+44.860	64.7460
730	208,468.5180	652,932.2110	48+34.368	60.2110
731	208,421.4190	653,136.2960	49+85.956	68.9430
732	208,364.2640	653,240.9320	51+05.184	81.6730
733	208,331.6110	653,353.0180	52+21.929	86.4030
734	208,248.8380	653,521.8320	54+09.944	87.0240
735	208,193.7020	653,591.9430	54+99.138	94.3310
736	208,148.6140	653,755.0580	56+68.370	95.9540
737	208,129.1400	653,855.4860	57+70.668	94.9290
738	208,078.7810	653,969.6610	58+95.456	95.1590
A734	208,042.6820	654,063.7570	59+96.239	0.0000
740	208,001.9103	654,159.8129	61+00.590	98.0000
801	207,901.1916	654,297.3051	62+71.026	0.0000

* 1 PRINT POINT 731 901-914 743 802

POINT	NORTH	EAST	STATION	ELEVATION
731	208,421.4192	653,136.2966	0+00.000	
901	208,356.3955	653,149.5989	50+52.326	75.1028
902	208,292.7378	653,267.7477	51+86.533	83.5359
903	208,242.4977	653,388.2875	53+17.124	81.1125
904	208,168.4985	653,516.3155	54+64.999	84.5228
905	208,150.5008	653,581.8798	55+32.988	89.8796
906	208,058.8829	653,739.4846	57+15.288	90.1655
907	208,049.5121	653,779.9303	57+56.805	87.3675
908	208,006.9102	653,873.1680	58+59.315	92.6640
909	207,939.9906	653,920.3662	59+41.204	97.7585
910	207,927.8275	654,064.0864	60+85.438	95.9184
911	207,860.1249	654,150.9653	61+95.582	91.5947
912	207,836.0790	654,230.2577	62+78.440	88.1397
913	207,799.3693	654,345.1186	63+99.024	86.2901
914	207,783.5580	654,388.6498	64+45.338	84.0800
743	207,768.9051	654,431.4359	0+00.000	
802	207,843.6535	654,443.4035	0+00.000	

Datum Description - Again

Baseline Data

Point Number
North/East/Elevation
BL Station Value

Text File:
Path and File Name

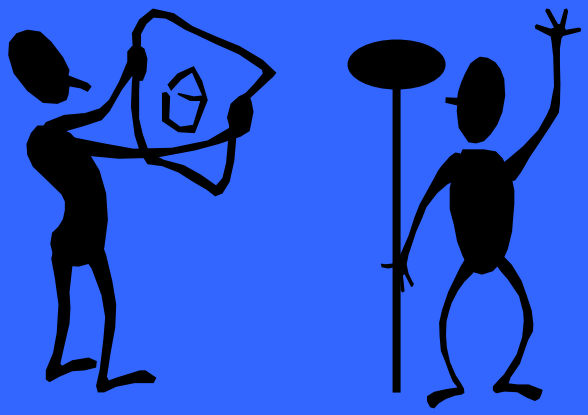
GPS in Construction

5800 Receivers – GPS only
R8-GNSS – GPS, Glonass, Upgradable
5800 in every RE office with R8 in every Division
New batteries, new software, new data collectors
All VRS Capable –
With Cell Phones and Data Stream

Total Station in every RE office with new data collector

What used to take a 4-person crew

might now take 2 persons



GPS
In Construction

Construction Stakeout and Tying Photo Controls

- Or Setting Calibration Points for GPS-Guided Graders

In Equipment Operation: Driver-operated or Remotely controlled -


HE didn’t have to wait on a survey crew!

GPS
In Construction

Horiz Accuracy ~ 0.03’
Vertical Accuracy ~ 0.07’

Note:
Due to Reduced Vertical Accuracy of GPS - Use Total Stations or Levels for Critical Elevations

Questions or Comments