Standards for Road Data Collection Using Global Positioning System Techniques

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Kentucky Transportation Cabinet

Department of Highways

Division of Planning

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ABSTRACT

The Division of Planning has been responsible for road inventories and the preparation of county highway maps since 1936 when the inventories first began. The initial set of county maps was completed in January 1940. Since that time, the Division has been the primary source of roadway inventory data for the Department of Highways and included the number of miles of state and local highways. For over the past 50 years, the Division has continued to update the data by conducting field inventories, which were then used to redraw the county highway maps and update state road mileage data files.

Because the data was available in this Division from our road inventories and our maps, the Division has always been responsible for providing mileage data and land area information after every Census to the Department of Finance for funding allocations for county and rural secondary roads under KRS 177.320. With the passage of legislation in 1986, Rural and Municipal Aid was given the responsibility for allocations under KRS 177.320(1). County Road Aid Maps are adopted by fiscal courts, by resolution, as their "official" county road system.

INTRODUCTION

The Kentucky Transportation Cabinet has automated a statewide GIS layer at the 1:24,000 scale. However, there is no quality assurance of Map Accuracy nor does Transportation's GIS layer match Kentucky's Statewide Digital Basemap standards (1:12,000), the digital orthophoto quarter quadrangles (DOQQ).

KYTC has recently started using GPS technology to reduce the cost and time involved in their field data-gathering effort to accurately measure over-the-road travel distances for local roads. However, at this time KYTC is not set up to maintain the data in a timely manner, either fiscally or staff-wise, only through partnerships can this be accomplished.

A GPS-based data collection system can be a very handy tool. In itself, a GPS receiver will not solve all data collection needs. Three Items are considered paramount for ensuring the success of Geospatial data.

- SAFETY – exercise as much caution as possible while driving along the roads. Don't be fooled. This is a TWO person operation. For example, if your trying to segment a road to indicate a surface change and assuming that the road is being recorded at about 45 miles per hour (at a recording rate of 3 seconds), your resulting data gap can be nearly 200 feet every time any of your attribute values change. Of course, the problems with your data quality will seem trivial the first time you are struck from the rear because you stopped on the motorway. This work involves collecting linear features from within a vehicle (**D**on't **D**rive and **C**ollect).

- EQUIPMENT - GPS accuracy can be complex. It is important that the GPS data collection unit provides real-time submeter accuracy. With GPS this requires accurate location of the antenna horizontally over any point. All user GPS measurements relate to the exact location of the antenna, therefore its precise relationship to the ground is critical to the process of obtaining quality results.

- STAFF - Standards and specifications are easily defeated by the ill prepared or untrained. Education gained through academics, personal experience, and the open exchange of ideas and experience of the users remains the best method for ensuring the proliferation of reliable data. It is hoped that these standards will contribute to this process.

DEFINITIONS

Accuracy

This is an indication of how close a measurement is to the true value.

Attribute

These are characteristics of features in a Geographic Information System (GIS). Every identifiable feature has attributes. One common attribute of all survey features is geographic position. Other attributes depend on the type of feature. For example, a road has a name or designation number, surface type, etc. Each attribute has a range of possible values, called domain.

Control Point (NGS Control Point)

An accurately known reference point used to compare field data to.

Data dictionary

Information that describes features located in the field is the data dictionary. This description includes data type classification (point, line, or area), attribute names, attribute types, and a list of valid attribute values. After being created on a PC, a data dictionary is downloaded to a data logger and used when collecting data in the field.

Differential GPS (DGPS)

The term "differential" is generally used with pseudorange methods, which resolve the errors in a single position. One of these methods is real-time DGPS, which resolve the errors in real time, in contrast to the approach of relative GPS. This is achieved by clear acquisition (C/A) code-phase (pseudo-range) error measurements at one or more stations and transmitting the data to the remote station(s).

Epoch

This is the measure interval of a GPS receiver.

LOCAL ROAD

Non-state maintained road.

PUBLIC ROAD

A “Public Road” is any road that is open to public travel. A road is usually not considered a public road if it; **(1)** serves only one home, business, or other facility, **(2)** Is signed as private, **(3)** is closed to the public by a gate or chain, unless it is maintained by a public authority (i.e. cemetery road owned by a local government or a county park) or **(4)** is impassable to a standard highway vehicle.

ACRONYMS

ADD

Area Development District

ESRI

Environmental Systems Research Institute

GIS

A Geographic Information System is an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.

GPS

Global Positioning System is based on a constellation of 24-28 satellites orbiting the earth at a very high latitude. GPS devices can be taken into the field to record data while driving, flying, or hiking. Ground locations are calculated by signals from satellites orbiting the earth.
http://www.navcen.uscg.gov/gps/geninfo/constell.htm

HIS

Kentucky Transportation Cabinet's Highway Information System.

SELECTIVE AVAILABILITY (SA)

Artificial degradation of the satellite signal by the United States of America Department of Defense.

WGS-84

The World Geodetic System (1984) is the mathematical ellipsoid used by GPS since 1984.

1. HORIZONAL ACCURACY STANDARDS

(Band IX)

The Kentucky Transportation Cabinet, Division of Planning accepts the Geospational positional accuracy standards proposed by the Federal Geodetic Control Subcommittee (FGCS 1994). Thirteen bands are defined by the radius of the relative positional error circle of 95% confidence. The tables below List accuracy bands from the FGCS proposal.

CLASSIFICATION BAND	95% CONFIDENCE	Unit	
Band 0	Reserved for CORS	meter	Outside the scope
Band I	<= 0.001	meter	of these
Band II	0.001 - 0.002	meter	Standards
Band III	0.002 - 0.005	meter	
Band IV	0.005 - 0.010	meter	
Band V	0.010 - 0.020	meter	
Band VI	0.020 - 0.050	meter	
Band VII	0.050 - 0.100	meter	
Band VIII	0.100 - 0.500	meter	
Band IX	**0.500 - 2.000**	**meter**	Horizontal accuracy
Band X	2.000 - 5.000	meter	Bands includes in
Band XI	5.000 - 10.000	meter	These standards
Band XII	> 10.000	meter	

Details regarding computation of the 95% confidence relative error circle can be found in the FGCS proposal.
For a more complete description the reader must consult the referenced document or its successor.
http://www.fgdc.gov/standards/status/sub1_1.html
http://www.fgdc.gov/standards/status/sub1_2.html
http://www.fgdc.gov/standards/status/sub1_3.html
http://www.fgdc.gov/standards/status/sub1_5.html
These specification standards for achieving Bands 0 through VIII are considered to be outside the scope of these specifications and therefore not considered.

Methods for collection of road centerlines are based on pseudorange measurements (Classification Band IX) and are included herein. These methods, either in post processed or real-time modes, are referred to as DIFFERENTIAL GPS (or DGPS techniques) and are generally not used for precise control surveys.

1.1 Techniques

It is the responsibility of the user to assess which GPS technique or combination of GPS techniques are required to achieve the FGCS Classification Band IX Standards for establishing a new GIS transportation layer for all public roads (both state-maintained & local).

1.2 Guidelines for equipment & equipment validation

Reading the advertisements of several GPS manufacturers can be very confusing. Worse yet you could be misled into believing that you understand more than you really do. Whether intentional or otherwise, advertisements often do not convey an intelligible picture of GPS accuracy. The issue of GPS accuracy can be complex.

- The Kentucky Transportation Cabinet is currently using the following GPS Equipment and software to achieve 1-meter horizontal accuracy (2dRMS) and is therefore the accepted standard.

- ***EQUIPMENT/Software***

- Trimble's GPS Pathfinder Pro XR/XRS System (Real-Time DGPS)

- Trimble's ASPEN Software

- OmniStar worldwide DGPS Service

- ***EQUIPMENT VALIDATION***

  To test the system being utilized and the post-processing software, the equipment should be validated on an appropriate land survey network (i.e. National Geographic Survey Control point). GPS observations totaling 1200 points (approximately 20 minutes collection time) shall be made at each Control Point. The results should be employed by the user to verify equipment accuracy and be retained for audit upon request. If repeated tests yield baseline results of more than 25cm, advice should be sought from the equipment manufacturer on the condition of the equipment.

- The epoch recording rate should normally be between 1 and 5 seconds.

- Observations to five or more satellites. Trimble's ASPEN Software

- GPS Field Book (Recording Sheet) shall contain the name and/or identifier (ID) used for each station, and include the receiver type, serial number, and the software used for reduction. This shall be made available upon request.

- The highest order of existing geodetic stations (Control Points) with known geocentric coordinates that are easily accessible and in close proximity to the road network should be utilized where possible. Include in your reporting all control points searched for but not found. If possible provide a reason why search was unsuccessful.

2. DATA COLLECTION

Field data collection is one of the most important and costly components in building and maintaining a GIS. Recent advances in GPS technology are helping the Transportation Cabinet, Division of Planning to reduce the cost and time involved in field data-gathering efforts and accurately measuring over-the-road travel distances. Customarily, when using GPS to record the road, users are in motion when recording line features, and it is common for individual attribute values to change at different locations along the line.

2.1 Techniques

It is KYTC's authority to dictate what collection techniques will be used to establish the new GIS transportation layer and maintenance schedule. The Area Development Districts (ADD's) will do this initial collection and maintenance work, in close cooperation with KYTC. As instructed below, KYTC requires a minimum of 1-meter accuracy for road centerlines, to be obtained via GPS. The ADD's will also collect road attribute information. The methods/procedures for road identification and attribute collection are outlined in section 2.3. As necessary, the Division of Planning retains the authority to revise those procedures throughout this collection and maintenance process.

2.2 Requirements

- All public roads such as; state maintained roads, county maintained roads, state park roads, city streets, federally owned roads (forest service, national park, etc.), private roads, private subdivision roads, coal mine owned roads (open to public travel), etc are to be included.

- The line representing the center of the road is to be collected. This is done by placing the antenna on the driver's side of the vehicle, and driving at normal traffic speeds. It is vitally important to make an effort to maintain a constant distance from the centerline, especially around curves.

  Note: It is our recommendation that the offset is best applied using Pathfinder Office software while processing field work in the office rather than setting an offset in the field using the Aspen software. This is recommended because the Pathfinder Office software will offset both field points (each point collected while driving at the 1 second epoch rate) and the arc that is derived from these points. Aspen will only offset the arc and not the field points themselves.

- KYTC recommends ASPEN software for the collection of road centerline GPS data. Pre-loaded background maps are suggested to make it easy for field workers to navigate and monitor data collection

- Divided Highways (where medians exist) are to be driven in both directions and not collapsed so that both directions will retain representation in the coverage. All state roads (non-divided) are to be driven in two directions and then collapsed using the KTC collapse script. All other roads are to be driven in one direction and the appropriate offset applied.

  Note: Some roadways may have more than one type of pavement and in this case the vehicle should come to a complete stop at the change of pavement and you should click on the SEGMENT button and enter the pavement that applies.

- Include all ramps, Y-intersections, crossovers, and connectors.

- At least 95% of the mileage of all state maintained roads should be located with GPS and 95% of the total mileage should be located with GPS. Alternative methods for determining positional accuracy can be employed, such as DOQQs, but must be identified in the "Mapsource" field

- Epoch recording rate is to be 1 second for all roads except for Interstates. The epoch rate for Interstate shall be 5 seconds.

- Raw observational data (rover files) shall be archived, in the event KYTC requires the ADD to reprocess the data, and should include the following: File statistics – features, settings, and. start/end time

- Antenna location & height (in feet & meters) – accuracy is limited to how close you can drive to the centerline or how precisely you can estimate and store the lateral offset from the centerline to the GPS antenna.

2.2 Requirements (continued)

- Use offset to center of roadway for adjusting collected coordinates to represent the location of the road centerline as follows:

Undivided, two-way, State-Maintained only:

- Driven on both sides
- Centerline is derived from an average of both lines
- Must be driven at constant offset from the **Left** side of the centerline

Undivided, Local (Non State-Maintained), and all one-way (State & Local)

- Driven in one direction
- Centerline derived from the offset
- Must be driven at constant offset from centerline

Divided, State & Local. Defined as the center of through lanes on each side:

- Driven once on each side
- Each centerline is derived using the offset
- Must be driven at constant offset from intended center line
- Odd number of lanes – set offset to the center of middle lane.
- Even number of lanes – set offset to line between center two lanes.

Note: See exhibits for detailed examples.

To ensure credibility for and to achieve the desired standards we have adopted and implemented a testing methodology in accordance with the National Standard For Spatial Data Accuracy (NSSDA), endorsed by the Federal Geodetic Control Subcommittee (FGCS), as certification of positional accuracy. To employ this testing methodology a **minimum** of 20 road intersections shall be located within each county with GPS equipment to be used as "control points". These locations should be distributed proportionately throughout each county to reflect the geographic area of interest and the distribution of error.

- There shall be a minimum of 180 positions taken at each intersection with a point logging interval rate of 1 second.

- The apparent intersection of the pavement centerlines is to be marked with a GPS Control Point (typically a P.K. Nail). This point of measurement does not represent the intersection of the road rights of way, and it is not to be used as a boundary point in a land survey of any adjoining parcel.

- Elevation (vertical) Data

  The vertical location of roadways shall be collected and retained in the GPS source files.

2.3 GPS DATA DICTIONARY

A data dictionary will be provided by KYTC to the ADD's and will include the following road centerline attribution:

- *Field 1*

  Name: LRS_ID

  Content: County Number, State, Local, and/or City Route Number

  Description: Linear Referencing System (LRS) Identifier

  Corresponding HIS field: RSE_UNIQUE

  Data Type: Character, 17

  Division of Information Technology

  The **LRS_ID** is recorded as follows XX-YYYYZZ-NNN.

  XX = Route prefix (up to two Characters followed by a hyphen)

  YYYY = Route number (up to four characters)

  ZZ = Route suffix's (up to two characters example: bypass, business route, etc.)

  NNN = Section Number

  Examples of LRS_ID: CR-1000, KY-2250, CS-1401, US-31E, US-31E-1

- *Field 2*

  Name: Co_rd_nm

  Content: Road Name (E911 name)

  Description: Full city street or county road name

  Corresponding HIS field: RSE_DESCR

  Data Type: Character, 40

- *Field 3*

  Name: SURFTYPE

  Context: Roadway surfacing type

  Corresponding HIS field: (Pavement, surftype)

  Data Type: Integer, 2

  Entries are:

  20 Unimproved

  40 Soil, Gravel, or stone

  52 Bituminous

  70 Concrete

  Reference Document: HIS- Inventory Types/Attributes/Values Report

- *Field 4*

  *Name: Owner**

  Content: Road Ownership Indicator

  Corresponding HIS field :RSE_GOV_LEVEL

  Data Type: Character, 2

  Values: Government Level of Control

- *Field 5*

  Name: Date

  Context: Date that the road was GPSed

  Corresponding HIS field: LINKDATE

  Data Type: Date, 8

- *Field 6*

  Name: Direction

  Content: Driving Direction Indicator

  Data Type: Character, 2

  Entries are:

  01 Cardinal

  02 Non Cardinal

  03 One Way

- *Field 7*

Name: MapSource

Content: Road centerline source

Corresponding HIS field: MAP_SOURCE

Data Type: Character, 1

Entries are:

1. *GPS*
2. *DOQQ*
3. *DRG*
4. *OTHER*

This field represents ownership and does not reflect agreements between government agencies for snow removal or other maintenance.

ROAD NUMBERING

Prefixes that may be used temporarily in the field*:*
NR = New Road (County or City) NC = Non County
(Note: NR and NC are not valid prefixes for a finished cover. Research must be done to identify the correct prefix code, owner and government level and reflected in the finished cover.)

County Road Numbering Scheme

(Numbering Shortage Procedures)

In counties where roads outnumber the currently used numbering scheme, and all original 1000 numbers have been assigned, the suffix “Q1, Q2, Q3, or Q4” for the corresponding quad, shall be assigned and the original numbering scheme of that county repeated. **All original 1000 numbers must be used first.** For instance, if the county numbering scheme has a pattern of:

Quad 1	1000-1099	1500-1599
Quad 2	1100-1199	1600-1699
Quad 3	1200-1299	1700-1799
Quad 4	1300-1399	1400-1499

1800-1899 (assigned to first quad that needed more than 200 numbers)

1900-1999 (assigned to second quad that needed more than 200 numbers)

and the numbers for the individual quads have been exhausted, then the numbers already assigned to each quad shall be repeated and a “Q” with the corresponding quad number added as a suffix. One example, assuming quad 3 had used all 200 numbers, originally assigned, plus the additional numbers (1800 and/or 1900 series) and it is then found that quad 3 needs still more numbers. The next step would be to use the numbers that have already been assigned to quad 3 with “Q3” added as a suffix (CR-1200Q3, CR-1201Q3, CR-1202Q3, and so on).
It is important that the original numbering scheme of the individual counties stay intact and then repeated once all other options have been exhausted. This would preclude using the same route number with different suffixes for different roads in an inset since the “Q1” would already occupy the suffix position. Therefore, neither the number “CR-1001Q1A” nor “CR-1001AQ1” are valid for use in an inset since the “Q1” is already in the suffix position. In this case, “CR-1001Q1” would be used and then the next sequential number “CR-1002Q1” would be used.

ROAD NAMES

Verify all road names with local officials. The **CO_RD_NM** is the road name used to identify the roadway. Note: If a road is signed differently than what is on our map index then change our road name to reflect what is on the sign. If you come to a new road not on our map and without a sign enter "UNNAMED ROAD" in this field and check with local officials to verify the correct road name. Use the listing of the State Primary Road System (SPRS) maintained and provided by the Division of Planning to identify state maintained roads.

OTHER AGENCY ROADS

Also include main drives to and within areas maintained by other state agencies such as state parks, state schools, state hospitals, correctional facilities, etc. Include boat ramps, but do not include service drives, parking areas , picnic areas, campgrounds, cabin drives, etc.
For many of these facilities, KyTC already has an Interagency Charge agreement and has assigned an IC-8___ number. Please check the listing of IC- numbers and use the assigned number if listed. If there are multiple roads for the facility, use suffixes A, B, C, etc. to distinguish. (Note: this listing is old and many entries may no longer exist.) If the facility is not listed, assign the number ST-8000 and KyTC will establish a new number. In any case, be sure to assign the appropriate Gov. Level: 11 for State Parks and State Forests and 21 for other state agencies.

FEDERAL AGENCY ROADS

Some roads that go through a National Forest or Park are maintained by the county. These should be coded with the assigned CR- number and Gov. Level = 02. Route identification of other roads owned and maintained by Federal Agencies that have had a number previously assigned by that agency should retain the agency number with an “FD” added in the prefix position. Also be sure to assign the appropriate Owner (Gov. Level) code.

NUMBERING PRIVATE ROADS

Private; Driveway, Road, and Subdivision Numbering Scheme

PR – A privately owned and maintained route that is public in use
PS – A privately owned and maintained development (e.g. trailer park, recreational development, or private subdivision) that is public in use.
PV – A privately owned and maintained route that is **not** public in use (factory entrance, driveway)

The numbering convention for “PR” (Private Road), “PS” (Private Subdivision), and “PV” (Private Driveway) should follow the same format as County Road Series maps (C.R.A.P. map) numbering. For example, the first private road in quad #1 should begin with the number of “PR-1001”, with following roads numbered consecutively (e.g., the second private road “PR-1002, and so on). The sequence of numbering the roads should be as follows:

Quad 1 PR-1001 – PR-1099
Quad 2 PR-1101 – PR-1199
Quad 3 PR-1201 – PR-1299
Quad 4 PR-1301 – PR-1399

Since the prefix field (PR, PS, or PV) allows the number to be unique the same rules will also apply to the “PS” and “PV” roads:

3. DATA PROCESSING

GPS data processing includes the review and cataloging of collected data files, processing phase measurements to determine line vectors and/or unknown positions, and performing adjustments and transformations to the processed vectors and positions. Each step requires quality control analysis, using statistical measures and prudent judgement to achieve the desired level of confidence.

3.1 Techniques

It is the responsibility of the ADD's to assess which GPS post-processing technique or combination of post-processing techniques will be used to fulfill KYTC's requirements for the new GIS transportation layer, as stated below.

3.2 Vectorization

Trimble Standard Storage Format (SSF) files (or COR) shall be converted to ESRI ARC/INFO coverages for additional graphic editing and data processing.

- Convert Arc Info cover to double precision
- Highway centerlines shall be cleaned and smoothed so that all lines are topologically correct.
- Produce a node at every at-grade intersection, only.
- Produced node at every county boundary, where it can be observed in-the–field. The next road intersection shall be classified as the county boundary where it cannot be physically observed.
- Use GPS data dictionary data structures, for line attributes
- For intersections (point feature), unique identifier only

3.3 GIS Map Specifications

- Map Format:Arc/Info Version 7.2.1 (minimum)
- Map Projection: State Plane Coordinate System (SPCS),(North or South)
- Map Units: U.S. Survey Feet
- Datum: North American Datum NAD83 NADCON
- SPCS Zone North:KIPDA, Bluegrass (most), Gateway, FIVCO, Buffalo Trace, Northern KY
- SPCS Zone South: All other ADD's, + Bluegrass (Mercer, Boyle, Garrard, Madison, Estill, Powell, Lincoln)

3.4 PROCESSING REQUIREMENTS

Control Points.

Collect control points once per week throughout the county to validate equipment operation. Also set up on an NGS Bench, B-order (HARN) in the county being inventoried, or an adjacent county, at least 2 times on the same point.

- **Delete Obvious Multipath in Pathfinder Office.**

Multipath that changes the character of the road (spikes) should be deleted in Pathfinder Office, since we re-export all of the GPS driving points from Pathfinder in order to run statistics. If the multipath is deleted later in ArcView or Arc Info, the bad points will remain in the original GPS rover files, and will affect statistics. Our review team wants the points to reflect the coverage as much as possible, so as to give the ADDs the best opportunity for passing the analysis. We would suggest that you review your data in Pathfinder often as it comes in from the field, adding precision's to the points then zooming in and panning around your GPS drives to find bad points. This will also give you the chance to weed out points that have high horizontal accuracy values, if by deleting them you don't damage the character of the road (such as in curves).

- **Provide a shapefile or coverage of only the GPS points you used to build the centerline coverage, or "build points".**

A large part of our review team's analysis of the ADD road coverages consists of reviewing the horizontal accuracy and alignment of the GPS points used to create the centerlines. If this point coverage isn't provided by the ADD, we have to spend at least several days weeding out points that were not meant for the purpose of building the arc (i.e. bad drives, re-drives etc.). *Bad points skew results*. The purpose of the build point coverage is to allow a quicker assessment of the project and a faster turn around time for a recommendation for approval or disapproval. Also, it would be easier for us to analyze the coverage if the build GPS points were exported from Pathfinder Office. Providing this exported shapefile (with all of the Pathfinder attributes, see last page) assures KYTC that the points are bonafide collected field points, and not edited in a shapefile or coverage. The following are attributes we request to have attached to build points:

LRS_ID (from spatial join)
Height
Standard Deviation
Horizontal Precision
Vertical Precision
Position (X,Y)
Datafile Name
PDOP
Correction Status
Receiver Type
Date Recorded
Time Recorded
Feature Name

We will buffer all roads from the finished coverage and clip out points that do not fall within the buffer, and then perform statistics for the full coverage to find the percentage of points that did not fall inside the buffer, along with statistics for each individual road. A report will then be generated if there are roads that we feel have a problem. We are determining if the arcs match the points that were collected in the field, and if not, why.

- **Use the comment field to explain:**

- "Gated" or "Impassable"

- County road lengths that don't match the current database (generated from the most recent C.R.A.P. maps).

- Explain unusual road conditions (under construction, left turning lane, GPSed but PDOP too high, etc.).

- **Arcs should be sufficiently cleaned up:**

- Undershoots and overshoots eliminated.

- Small jags around intersections eliminated.

- Duplicate arcs searched out and eliminated.

- Remove excess nodes- all arcs unsplit, when doing so will not lose attribution such as change in pavement, change in Mapsource, Change in Datafile, etc.

- Arcs should be split at city boundaries.

- ADDs may need to revisit their snap tolerances especially at intersections.

- Do not delete the log file in ArcInfo coverage folders

- Separate the arcs from the points (intersections & controls) in the Trimble files, placing each in a different folder.

- Export the data file field on all files out of Pathfinder office. Include all export text files (*.inf & exp*.txt) and methods of corrections (cor*.txt). These fields and files, along with the build points, will allow us to check the ADD coverages much more quickly.

- Split arcs to correctly show the different datafiles that were used to define that section of road. This also allows us to make sure we are using the right GPS points for our analysis.

- Correctly define the map source for each arc. If you have to go in and digitize a segment of road because the topography wouldn't allow you to get a good GPS lock, please cut that segment and label it *DOQQ*.

- Don't include nodes at non-grade intersections (over and underpasses). This is a connectivity issue.

- The map coordinate precision has been changed from single to double precision.

- All state maintained routes should be portrayed according to official order.

- All routes should be correctly labeled as to the correct owner and prefix.

- Routes should have arcs pointing in correct direction. All state maintained routes should be pointed in the cardinal direction. Arcs on non-state maintained roads should point away from state maintained roads.

- Populating the Comment field is essential when county maintained routes have major alignment and length differences (< or > 0.1 miles) when compared to the most recent County Road Aid Series maps.

- Provide a list of roads that are on the most recent County Road Aid Series map, but are not included in the new coverage, with documentation as to reason.

- Per instructions from the Department of Rural and Municipal Aid, there should be no county roads (CR prefix) within a city boundary. The county may provide maintenance per an agreement, however roads within a city boundary should be prefixed CS and Government Level 04.

- Arcs should be attributed with correct road name and number (i.e. prefix corresponds with owner).

- Please contact your POD or Central Office for support

4. DOCUMENTATION

A written project report is required from each ADD. It should be completed by the personnel directly responsible for supervising the KYTC GPS/GIS centerline work and provided to the managing ADD, if applicable, where it should be reviewed and delivered to the Division of Planning. The final report will be documentation of the successful completion of the project, and will include, at a minimum, the following:

- A narrative description of the project which summarizes the project extent, objectives, methodologies, and conclusions.

- A listing and discussion of the equipment and staff used.

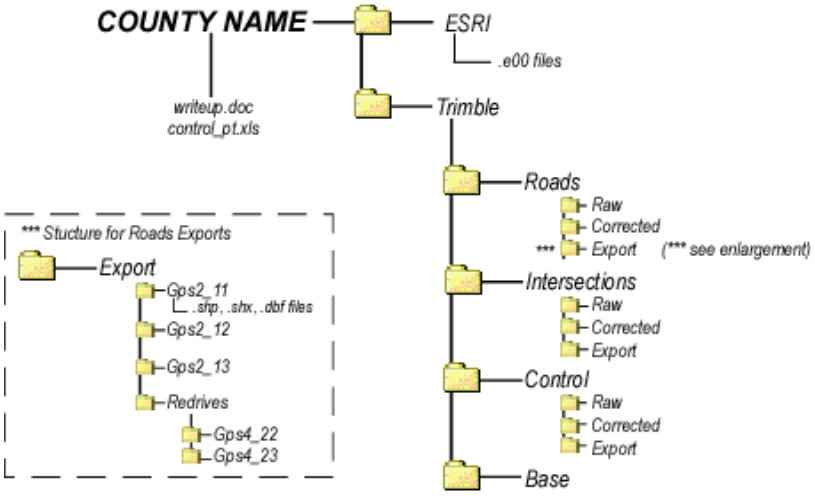
- Description of data processing. Note the software used (i.e., Pathfinder, Arc/info , Arcview), the version number and the techniques employed.

- Provide a summary of the GPS road centerlines attribution, including the total miles.

- Identify any data or road centerlines excluded from the county road network with an explanation for exclusion.

- Include a digital map of the county, at an appropriate scale (1:125000 or 1:62500), identify all road network and control points, including road intersections. A sample of this desired cartographic output will be provided by the Division of Planning to the ADD's.

- An accompanying CD-ROM including all data files, GPS rover files, maps, etc. shall be submitted with the project report. A meeting should be scheduled with Co personnel to provide the data and review the information. The CD-ROM shall be formatted in the following Manner:



Useful Hints

- Adding precision records: In Pathfinder, after correcting the data, go to the dropdown list *Utilities/other/check .ssf files/add precision records.* This will create a new set of corrected rover files with an underscore before the filename. Open the new files and turn on *View/layers/precessions*. This will give you precision circles around each point in proportion to its horizontal accuracy. Large circles = poor precision.

- Exporting attributes in Pathfinder: in *export menu/change setup options/attributes* check all of the attributes except for *Area Features*.

- It is our recommendation that the offset is best applied using Pathfinder Office software while processing field work in the office rather than setting an offset in the field using the Aspen software. This is recommended because the Pathfinder Office software will offset both field points (each point collected while driving at the 1 second epoch rate) and the arc that is derived from these points. Aspen will only offset the arc and not the field points themselves.

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