FLORIDA DEPARTMENT OF TRANSPORTATION



# SURVEYING AND MAPPING HANDBOOK

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# ABBREVIATIONS

- 2D 2 Dimensional
- 3D 3 Dimensional
- ASCII American Standard Code for Information Interchange
- ASPRS American Society of Photogrammetry and Remote Sensing
- AT Aerial Triangulation
- BM Bench Mark
- BSM Bureau of Survey and Mapping
- CADD Computer Aided Design and Drafting
- CORS Continuously Operating Reference Station
- DEM Digital Elevation Model
- Department Florida Department of Transportation
- DMI Distance Measuring Instrument
- DSMO District Surveying and Mapping Office
- DTM Digital Terrain Model
- EFB Electronic Field Book
- EOR Engineer of Record
- F.A.C. Florida Administrative Code
- FDEP Florida Department of Environmental Protection
- FDOT Florida Department of Transportation
- FGDC Federal Geographic Data Committee
- FHWA Federal Highway Administration
- FKP Flächen Korrektur Parameter
- FPRN Florida Permanent Reference Network
- F.S. Florida Statutes
- GDOP Geometric Dilution of Precision
- GLONASS Global Orbiting Navigation Satellite System
- GNSS Global Navigation Satellite SystemGPS Global Positioning System
- iMAC Individualized Master Auxiliary Concept (iMAX)
- IMU Inertial Measurement Unit

- LiDAR Light detection and Ranging
- MOT Maintenance of Traffic
- MAC Master Auxiliary Concept (MAX)
- MHWL Mean High Water Line
- NAD North American Datum
- NAVD North American Vertical Datum
- NDP Network Design Plan
- NGS National Geodetic Survey
- NGVD National Geodetic Vertical Datum
- NSRS National Spatial Reference System
- NSSDA National Standard for Spatial Data Accuracy
- OHWL Ordinary High Water Line
- OPUS Online Positioning User Service (NGS Web-based Software)
- OPUS-P Online Positioning User Service Projects (NGS Web-based Software)
- OPUS-RS Online Positioning User Service Rapid Static (NGS Web-based Software)
- PC Point of Curvature
- PDOP Positional Dilution of Precision
- PI Point of Intersection
- PNC Project Network Control
- POC Point on Curve
- POT Point on Tangent
- PT Point of Tangency
- PSM Professional Surveyor and Mapper
- QA/QC Quality Assurance/Quality Control
- RGPS Real-Time GPS
- RINEX Receiver Independent Exchange Format
- RMS Root Mean Square
- RMSE Root Mean Square Error
- RS Rapid Static

- RSGPS Rapid Static GPS
- RT Real-Time Positioning
- RTK Real-Time Kinematic
- RTN Real-Time Network
- R/W Right of Way
- Scope Project Scope of Services
- SGPS Static GPS Observation
- SMO Surveying and Mapping Office
- SRD State Road Department
- SUEL Safe Upland Elevation Line
- TBM Temporary Bench Mark
- TIITF Trustees of the Internal Improvement Trust Fund
- TRB Transportation Research Board
- USGS United States Geological Survey
- VRS Virtual Reference System
- X,Y,Z Cartesian Coordinates

# DEFINITIONS

- **Accuracy** Degree of conformity with a standard or accepted value. Accuracy relates to the quality of a result, and is distinguished from precision which relates to the quality of the operation by which the result is obtained.
- Artifacts Erroneous data points that do not correctly depict the scanned area. Objects moving through the scanner's field of view, temporary obstructions, highly reflective surfaces, and erroneous measurements at edges of artifacts (also known as "edge effects") can cause artifacts.
- **Axis Test** Method of calibration in which multiple direct and reverse angular readings are used to correct systematic errors in a total station.
- **Bathymetry** The art or science of determining ocean depths.
- LAS A binary file standard supported by the American Society of Photogrammetry and Remote Sensing (ASPRS) for storing point location and attribute information primarily used for LiDAR data.

- **LiDAR** An active optical remote sensing technology which measures the return properties of scattered light to determine range, direction, and other information of a distant line-of-sight object
- Localization A coordinate transformation from the GNSS reference system to the project specified system as defined by Department approved control.
- Mean High Water (MHW) The average height of the high waters over a 19 year period.
- **Mean High Water Line (MHWL)** The intersection of the tidal plane of mean high water with the shore.
- **Ordinary High Water (OHW)** The highest reach of a navigable, nontidal waterbody as it usually exists when in its ordinary condition.
- Ordinary High Water Line (OHWL) The intersection of the plane of ordinary high water with the shore in areas without tidal influence.
- **Positional Accuracy** A statistical estimate of how close the measured position of a point or object is to its true location in a defined spatial system or datum.
- **Precision** A measure of the uniformity or reproducibility of the result. Precision relates to the quality of the operation by which the result is obtained and is distinguished from accuracy which relates to the quality of the result.

# PURPOSE

This handbook sets forth basic guidelines for performing surveying and mapping activities, developing products, and quality assurance/quality control for the Department. It is not intended to be a comprehensive technical manual but is to act as a directive for requirements, guidelines, and best practices. For specific project instructions, see the DSMO.

# AUTHORITY

Section 20.23(4)(a), F.S. Section 334.048(3), F.S.

# SCOPE

This handbook applies to anyone performing surveying and mapping services for the Department under the Surveying and Mapping Workgroup or referenced or as directed in other guidelines, specifications, or contract requirements.

# REFERENCES

Chapter 20, F.S. – Organizational Structure Chapter 177, F.S. – Land Boundaries Chapter 287, F.S. – Procurement of Personal Property and Services Chapter 334, F.S. – Transportation Administration Chapter 337, F.S. – Contracting; Acquisition; Disposal; and Use of Property Chapter 472, F.S. – Land Surveying and Mapping Rule Chapter 5J-17, F.A.C. – Board of Professional Surveyors and Mappers Rule Chapter 14-75, F.A.C. – Qualification, Selection and Performance Evaluation Requirements for Professional Consultants to Perform Work for DOT Surveying and Mapping Procedures, Topic No. 550-030-101-c CADD Manual, Topic No. 625-050-001 EFB User's Handbook

# GENERAL

This handbook supersedes the previous *Surveying Handbook* dated 10/31/2003 and the Right of Way Mapping Handbook dated January 2003.

# **REQUIREMENTS FOR SURVEYS**

All surveys done for the Department will be conducted in accordance with the *Standards* of *Practice* set forth in *Rule Chapter 5J-17, F.A.C.*, pursuant to *Section 472.027, F.S.* 

There may be requirements set forth by the Department that are more stringent than those defined in the *Standards of Practice* that must be adhered to as well.

# DISTRIBUTION

This handbook will be made available by the Surveying and Mapping Office. The Department will consider input from all users concerning the regular upkeep of this handbook. Appropriate contact information will be included in the handbook for users to submit suggestions for revisions to the handbook. Items warranting immediate revision, or revisions mandated by state or federal law, will be made to the handbook after review by the State Surveyor, in the form of revisions to this handbook or **Surveying and Mapping Bulletins**. These revisions may be temporary in nature or may carry over until the next handbook revision.

# TRAINING

See *Maintenance of Traffic Training, Topic No.* 625-010-010 for information on Maintenance of Traffic training and certification.

# FORMS

See the DSMO for applicable forms.

# SURVEYING AND MAPPING

# 1. CONTROL

#### 1.1. HORIZONTAL PROJECT CONTROL (27.1)

Horizontal positions are referenced to the Florida State Plane Coordinate System, NAD 83, 1990 or later readjustment or realizations. Some existing projects may be referred to NAD 27. When two or more datums are encountered on a project, additional survey may be required to determine their relationship.

In some jurisdictions there are control points which are on a local or assumed datum. A local or assumed datum will only be used with written authorization from the DSMO. Exercise caution when using a local or assumed datum.

Since there is no direct mathematical method to accurately transform coordinates from one system to the other, the use of data conversion programs, such as NADCON and CORPSCON, is discouraged. However, they could be used for specific projects where a general accuracy of  $\pm 0.5$  ft. is acceptable. This will require written authorization from the DSMO.

Project Network Control Data Sheets will be filled out for all primary control set for a project. See the DSMO for data sheets and instructions.

**Note:** The Department strongly encourages its consultants to report to NGS and the DSMO any destroyed monuments that are recorded in the published data.

See *Appendix C* for horizontal control accuracy requirements.

#### 1.2. VERTICAL PROJECT CONTROL (27.2)

Elevations are referenced to NAVD 88. Some existing projects may be referred to NGVD 29. When two or more datums are encountered on a project, additional survey may be required to determine their relationship.

In some jurisdictions, there are bench marks which are on a local or assumed local datum. A local or assumed datum will only be used with written authorization from the DSMO. Exercise caution when using a local or assumed datum.

Since there is no direct mathematical method to accurately transform elevations from one system to the other, the use of data conversion programs, such as VERTCON, is discouraged. However, they could be used for specific projects where the required project accuracy could be met using this method. This will require written authorization from the DSMO.

**Note:** The Department strongly encourages its consultants to report to NGS and the DSMO any destroyed monuments that are recorded in the published data.

See *Appendix C* for vertical control accuracy requirements.

#### 1.3. AERIAL NETWORK CONTROL (27.4)

Place, locate, and maintain aerial targets and/or photo identifiable points. This includes analysis and processing of all field collected data, existing maps, and/or reports. Placement of these targets will be at the direction of the aerial firm.

See *Appendix C* for horizontal and vertical accuracy requirements.

#### 2. ALIGNMENT

#### 2.1. RETRACEMENT

The suggested order of importance is:

- 1. Alignment monumentation as shown on previous Department surveys or right of way maps
- 2. Alignment reference points from previous projects
- 3. SRD and FDOT right of way monuments
- 4. Subdivision monuments and land lines shown on previous Department surveys
- 5. Significant improvements shown on the existing construction plans
- 6. Evidence along the right of way not shown on previous Department surveys
- 7. State plane coordinates from previous right of way documents

#### 2.2. MONUMENTATION (27.3) AND REFERENCE POINTS (27.5)

Set suitable marks at PC's, PT's, PI's, and POT's and POC's at ±1000 foot intervals; reference these points as required. Reference points should be set at right angles or radial to the baseline whenever possible.

#### 2.3. STATIONING (27.3)

Survey stationing proceeds from south to north and from west to east on Department projects. The prevailing direction of the route governs the direction of the survey and the stationing. Thus, all surveys for a particular route in are stationed in the same direction.

If the survey begins on an existing route, then the existing stationing is normally used.

#### 2.4. DEFINITION OF CURVATURE

Arc definition curves are the standard used on current Department projects. On older projects, chord defined curves may have been used. Where chord defined curves are encountered on existing maps, it is necessary to convert the curve data to the arc definition. The most practical method is to compute new curve data, holding the central angle and tangents.

#### 2.5. ALIGNMENT SUBMITTAL/APPROVAL

The deliverable includes:

- a description of all points found.
- a comparison of the field data to the record data.
- a report or narrative describing the process by which the alignment was retraced.
- a sketch or map of the preliminary alignment, including the alignment geometry which consists of stationing, bearings, distances, complete curve data, and coordinates.

When the preliminary alignment has been approved, a final alignment can be shown in the field book with complete geometry and pertinent notes.

# 3. TOPOGRAPHY

#### 3.1. FIELD DESCRIPTIONS

All surfaces should be identified, e.g., sod, pavement type, rock, and soil. Be specific in the description.

Buildings and improvements within 50 feet for urban projects, or 100 feet for rural projects, outside of the existing or proposed right of way line should be located, unless otherwise instructed. Buildings (including overhangs where pertinent) should be listed by type, use, and street address.

When locating fences, describe the kind, type, height, and condition since these fences are usually moved, salvaged, or rebuilt during construction.

Wood lines, changes in types of cultivation, and breaks in terrain should all be indicated. In orchards and groves where trees are spaced in rows, it is necessary to locate the trees affected by the design. Indicate the type of trees and their diameter. Measure tree diameter at breast height (4 ½ feet above the ground on the uphill side). All ties are to be made to the center of the tree. Locate all landscaping such as shrubs, flower beds and hedgerows.

All above ground utility features should be located and identified.

When measuring to any improvement which is circular, e.g., poles, manholes, tanks, fire hydrants, ties should be made to the center.

#### 3.2. DIGITAL TERRAIN MODEL – 3D (27.6)

DTM's are used when both horizontal and vertical data are required to fix known drainage or slope issues, to redesign or adjust slope/drainage conditions, and for new design. DTM's are derived from points and breaklines, and are developed from data collected by ground or aerial survey. All pertinent features and improvements should be located with a density sufficient enough to produce an accurate DTM.

Check cross-sections (27.8) or profiles should be performed to verify the accuracy of the DTM.

#### 3.3. ROADWAY CROSS-SECTIONS (27.8)

Cross-sections are an organized field data collection technique used for obtaining 3D data along linear features such as roadways, ditches, and embankments.

Cross-sections provide information for:

- surface model creation or verification
- cross-slope inspection
- sign placement
- comparison to proposed typical sections
- specific point elevations
- side street returns
- contour generation
- earthwork calculation
- bathymetry
- drainage structures

See *Appendix C* for horizontal and vertical accuracy requirements.

#### 3.4. PLANIMETRIC – 2D (27.7)

Planimetric surveys are used when no vertical data is required for design. This is sufficient when existing slope/drainage data is available and only minor changes are being performed to a road section, such as resurfacing. In these instances, all above ground features and improvements are located horizontally.

See *Appendix C* for horizontal accuracy requirements.

#### 3.5. SIDE STREET SURVEYS (27.9)

Side street surveys are necessary when design will continue beyond the project specific corridor width. In these instances data is collected per the requirements in either **Section 3.2** or **Section 3.4** of this document, depending on the application.

See *Appendix C* for horizontal and vertical accuracy requirements.

#### 3.6. UNDERGROUND/SUBSURFACE UTILITIES (27.10)

Subsurface utility locations are needed on most projects, in support of design criteria decisions that reduce construction delays and financial risks as well as enhance jobsite safety. For subsurface utilities, the research information, locating tools, and methods used dictate the accuracy of the utility data. Subsurface utilities within the project limits should be identified, and/or located, and properly depicted with their proper "quality levels" so that the engineer can make informed decisions through all phases of a project by having confident knowledge of the utility data accuracy. Only subsurface utilities are referenced to quality levels. The project engineer should depict in the scope what and where differentiating quality level data is needed for the project. Additional underground/subsurface utilities may be located in advance of geotechnical operations.

See Section 5.3 of the Surveying and Mapping portion for Geotechnical Support.

#### 3.6.1. SUBSURFACE UTILITY QUALITY LEVELS

- **QL D** Information obtained solely from a review of utility records. The comprehensiveness and accuracy of such information is highly limited. Even when existing information for a utility in a particular area is accurate, there are underground systems that are not shown on any records. Level D may be appropriately used in the early development of a project to determine the presence of utilities.
- **QL C** Information obtained to augment level D information. This involves topographic surveying of visible, above ground utility features, e.g., poles, hydrants, valve boxes, circuit breakers, etc., and entering the topographic data into the CADD system. Level C may be appropriately used early in the development of a project and will provide better data than level D information alone. Designers must be very cautious when working on projects using information for underground utilities that is based only on level C and D locates.
- QL B Information obtained through the use of designating technologies, e.g., geophysical prospecting technologies. This is a field activity using remote sensing geophysical scanning technologies, most of which have very specific capabilities and offer various strengths and weaknesses. Applying a variety of techniques is essential to the process of preparing a comprehensive horizontal map of utilities and other underground structures on the site as these tools may react differently to the type of

utility conductor, soil conditions, and adjacent utilities or surrounding environments that impact accuracy and disrupt electromagnetic radio frequencies. Designating technologies are capable of providing marginal to good horizontal information but provide limited vertical information and therefore vertical accuracy is not suitable to address potential conflicts in vertical design.

**QLA** Provides the highest level of accuracy of utility locations in three dimensions. This level may apply to manual, mechanical, or nondestructive, e.g., vacuum excavation, methods to physically expose utilities for measurement and data recording. Levels B, C, and D are incorporated into level A locates. The designer should obtain level A locates at highway and utility conflict points where verified information is needed to make confident design decisions.

#### 3.7. DESIGN SURVEYS

#### 3.7.1. OUTFALL SURVEYS (27.11)

Outfall surveys are conducted to measure the size, shape, flow, capacity and locate the destination of an above ground storm drainage system. This may be required for an existing ditch.

See *Appendix C* for horizontal and vertical accuracy requirements.

#### 3.7.2. DRAINAGE SURVEYS (27.12)

Drainage surveys are conducted to determine the description of, location, flow and capacity of storm water structures, within project specific limits. This will require the 3D location of the flowline(s) of the structure, as well as the size, material, and condition. It is most important to show the nominal pipe size, do not give the skew width or the bell diameter.

To understand the drainage information required on a particular job, discussion with the DSMO and the District Drainage Engineer may be required.

See *Appendix C* for horizontal and vertical accuracy requirements.

#### 3.7.3. BRIDGE SURVEYS (27.13)

Bridge surveys are conducted to gather data pertaining to bridge structures within project specific limits. This will require the location of above ground features and improvements for the project limits. Requirements for bridge surveys are project specific.

See *Appendix C* for horizontal and vertical accuracy requirements.

It may also be necessary to perform water boundary surveys in conjunction with bridge surveys in order to satisfy project requirements. See **Section 4.2.1.** for information on water boundary surveys.

#### 3.7.4. CHANNEL SURVEYS (27.14)

Channel surveys are conducted to determine the description, location, and capacity of water features, manmade or natural, to/from or through specific projects limits. This will require the location of features and improvements both above ground and/or below the water's surface for the project limits.

Requirements for channel surveys are project specific.

See *Appendix C* for horizontal and vertical accuracy requirements.

It may also be necessary to perform water boundary surveys in conjunction with channel surveys in order to satisfy project requirements. See **Section 4.2.1.** for information on water boundary surveys.

#### 3.7.5. POND SITE SURVEYS (27.15)

Pond site surveys are used to determine the capacity & capability of a specific storm water retention area. This will require the location of features and improvements, both above ground and/or below the water's surface for the project limits.

See *Appendix C* for horizontal and vertical accuracy requirements.

#### 4. BOUNDARY SURVEYS (27.22)

Boundary surveys for the acquisition or disposal of a parcel of land may be required. Specifications for this work will be defined by the *Standards of Practice* adopted by the Florida State Board of Professional Surveyors and Mappers.

See Appendix C for horizontal accuracy requirements.

#### 4.1. SECTIONAL/GRANT SURVEYS (27.19)

Sectional/Grant surveys include field location/placement of monumentation for section corners, quarter-section corners, and fractional corners where pertinent, and includes analysis and processing of all field collected data and/or reports.

See *Appendix C* for horizontal accuracy requirements.

#### 4.2. SUBDIVISION LOCATION SURVEYS (27.20)

Subdivision location surveys include field location/placement of monumentation along existing recorded subdivision/condominium boundaries, tracts, units, phases, blocks,

street right of way lines, common areas, etc., and includes analysis and processing of all field data and/or reports. If an unrecorded subdivision is on file in the public records of the subject county, any existing monumentation of its parent tract should be located.

See *Appendix C* for horizontal accuracy requirements.

#### 4.2.1. WATER BOUNDARY SURVEYS (27.23)

#### 4.2.1.1. MEAN HIGH WATER LINE SURVEYS

The MHWL establishes the boundary between state sovereignty lands and those of private ownership in areas of tidal influence.

All MHWL surveys must be performed in accordance with *Chapter 177 Part II, F.S.*; FDOT; and the FDEP, BSM standards. Contact FDEP, BSM for MHWL elevations and information.

See *Appendix C* for horizontal and vertical accuracy requirements.

#### 4.2.1.2. ORDINARY HIGH WATER LINE SURVEYS

The OHWL is the point up to which the presence and action of the water is so continuous as to destroy the value of the land for agricultural purposes by preventing the growth of vegetation constituting what may be termed an ordinary agricultural crop. This establishes the boundary between state sovereignty lands and private ownership in areas of navigable waters.

Contact FDEP, BSM for OHWL elevations and information.

See *Appendix C* for horizontal and vertical accuracy requirements.

#### 4.2.1.3. SAFE UPLAND ELEVATION LINE SURVEYS

In the course of obtaining an easement over sovereign submerged lands a SUL or SUEL survey may be performed rather than a MHWL or OHWL survey, at the direction of FDEP BSM. A SUL or SUEL is a line that is landward of the sovereign boundary and is used in the easement legal description to ensure all the interest of the sovereign is obtained.

SUEL/SUL's are not to be considered a sovereignty submerged land boundary and will not be recognized by FDEP for use in controlling future development or for any other use or purpose unless specifically stated by FDEP. Contact FDEP, BSM for SUEL elevations and information.

See *Appendix C* for horizontal and vertical accuracy requirements.

# 5. SPECIFIC PURPOSE SURVEYS

#### 5.1. MITIGATION SURVEYS (27.16)

Mitigation surveys are conducted to locate areas where any given type of environmental impact must be averted or minimized for its protection or the protection of the public. Design professionals frequently rely on these for planning and site design.

See *Appendix C* for horizontal accuracy requirements.

#### 5.2. JURISDICTION LINE SURVEYS (27.17)

Jurisdiction line surveys are conducted to locate limits of wetlands, usually to satisfy the requirements of governmental authorities. Perform 2D field location of jurisdictional limits as defined by respective authorities. This includes field edits, analysis and processing of all field collected data and/or reports.

See *Appendix C* for horizontal accuracy requirements.

#### 5.3. GEOTECHNICAL SUPPORT (27.18)

Perform 3D field location, or stakeout, of boring sites established by a geotechnical engineer. This includes field edits, analysis, and processing of all field collected data and/or reports.

See *Appendix C* for horizontal and vertical accuracy requirements.

#### 6. **RIGHT OF WAY**

#### 6.1. MAINTAINED RIGHT OF WAY (27.21)

Perform 2D field location of maintained right of way limits as defined by the maintaining authority. This includes field edits, analysis and processing of all field collected data and/or reports.

See **Section 2.3 of the Right of Way Mapping** portion of this document for information on maintained right of way surveys.

See *Appendix C* for horizontal accuracy requirements.

#### 6.2. RIGHT OF WAY STAKING, PARCEL/RIGHT OF WAY LINE (27.24)

Perform field staking and calculations of existing and/or proposed right of way lines for on-site review purposes.

See *Appendix C* for horizontal accuracy requirements.

#### 6.3. RIGHT OF WAY MONUMENTATION (27.25)

Set right of way monumentation as depicted on final right of way maps for corridor, water retention areas, and perpetual easements.

See Appendix C for horizontal accuracy requirements.

# 7. MISCELLANEOUS SURVEYS (27.28)

On occasion, it may be necessary to perform surveys other than those previously covered herein. Specifications for this work will be defined by the *Standards of Practice* adopted by the Florida State Board of Professional Surveyors and Mappers.

See *Appendix C* for horizontal and vertical accuracy requirements.

# 8. SUPPLEMENTAL SURVEYS (27.29)

Incidental surveys that cannot be readily anticipated when scoping the project.

See *Appendix C* for horizontal and vertical accuracy requirements.

# 9. SURVEY REPORT

The purpose of a survey report is to adequately communicate the survey methods and results as judged by the surveyor and mapper. To accomplish this, information may be needed such as: data sources, measurement methods, history and lineage of data, limitations pertaining to the information presented, and a list of all included deliverables.

Reports should give a clear description of the methodology used as it relates to both field and office procedures. There should be no doubt in the reader's mind as to the intent of the survey and how it was accomplished.

All survey reports should contain standard content that satisfies the requirements of the *Standards of Practice* adopted by the Florida State Board of Professional Surveyors and Mappers and those of the Department. Nothing precludes the Department from requiring more stringent standards than those set forth in the *Standards of Practice*. See the *Survey Report Checklist* for content requirements.

Report items are information, as required by other parts of this rule, such as: abbreviations, legends, accuracy statements, feature lists, datums used, and things done or not done as part of the surveying and mapping process. Text report items shall be displayed either through notes on the map, report, or in a text report delivered with the map.

When the report is produced as a text document and a map is attached, the report shall be signed and sealed. When the map is delivered in digital form only, then a report is required. For digital map deliveries all notes formerly shown on paper maps should be included in the report. Each surveying entity submitting electronic data to the Department must prepare a survey report.

When a survey project involves multiple surveyors or firms, a lead surveyor will be identified. A comprehensive survey report will be prepared by the lead surveyor and

should detail the total survey, describing the roles and responsibilities of each surveying entity and will reference and include as attachments, all survey reports prepared by the other surveyors involved in the project.

# **10. OFFICE PROCEDURES**

#### 10.1. DOCUMENT RESEARCH (27.30)

Perform research of documentation to support field and office efforts involving surveying and mapping.

#### 10.2. TECHNICAL MEETINGS (27.32)

Attend meetings as required and negotiated by the DSMO.

#### 10.3. QUALITY ASSURANCE/QUALITY CONTROL (27.33)

A QA/QC plan is required from the consultant for each project prior to the commencement of work. This details the proposed methods of providing quality control for all work products. This plan will be kept current with the work requirements.

The main objective of QA/QC is to provide a mechanism by which all products for the DSMO can be subject to a systematic and consistent review. The QA/QC review minimizes errors and creates a quality survey.

A secondary objective is to provide for a well-documented trail of the survey process. A properly documented project file should be a by-product of the QA/QC plan. The Department should be able to substantiate its position from properly documented project files if any legal, social or procedural issues arise regarding the project.

#### 10.3.1. QUALITY CONTROL REVIEWS

Every product will undergo a QA/QC review by the consultant as part of the QA/QC plan. The reviewer should be experienced in QA/QC review. Procedures for these quality control reviews are discussed in the sections below.

#### 10.3.1.1. CHECKING SURVEY REPORTS

Once the report writing has progressed to an appropriate stage of development, a draft is sent to the reviewer. Review comments and corrections are marked on the review draft in red. Upon completion of the review, the reviewer signs and dates the cover page of the draft and returns the draft to its originator. The originator then confirms or revises the corrections and comments, adds their own corrections and comments, and makes the corrections to the text. The marked-up draft is placed in the project file after the document is finalized. This marked-up draft is submitted to the Department as part of the final project deliverables.

#### 10.3.1.2. CHECKING DRAWINGS

Drawings are developed progressively by an interactive process using sources of information such as survey data, reports, record data, preliminary sketches, samples, official maps, etc., in conformance with the requirements, survey criteria, and standards and guidelines required by the Department. Before a drawing is considered final, it will be independently checked for:

- Conformance with the mapping criteria and project requirements, including CADD Standards
- Completeness and clarity
- Coordination with other aspects of the project
- Compatibility standards and good mapping practice

#### 10.3.1.3. CHECKING SURVEY DATABASES

The project surveyor and survey technician will develop a checklist pertaining to the survey database. The checklist will be updated using comments from Department reviewers throughout the life of the project.

#### 10.3.1.4. CHECKING CORRESPONDENCE

All correspondence will include the financial project number as well as a local name when referring to a project. Any correspondence that is prepared for external customers should be reviewed by another employee for spelling and grammar mistakes.

#### 10.3.2. PROPOSED METHODS OF DOCUMENTATION

#### 10.3.2.1. DOCUMENTATION OF COMMENTS AND RESPONSES

All comments made by external reviewers will be recorded either by copy of memos, email, letters or marked drawings. In the event that comments are received through meetings, there will be minutes prepared that summarize the comments received. All comments will be responded to in writing in a format that identifies the document review date, reviewer's comments and responses to the comments. All comment/response drafts will be added to the project file.

#### 10.3.2.2. QA/QC RECORDS

The project surveyor will be responsible for maintaining the QA/QC records. At any point in the surveying process, the project surveyor will make records available to the DSMO for a QA/QC review. All submittals may be subject to QA/QC audits by the Department.

When any review by the Department is performed, consultants must not rely on the Department as a part of their QA/QC plan either formally or informally. Survey consultants are expected to follow their own QA/QC plan.

Strong emphasis will be placed on coordination with all of the sub-consultants throughout the project. Particular attention will be placed on critical path activities and on the sub-consultant's needs for information required for participating in these and other activities in a timely manner. Regular meetings will take place in order to facilitate this coordination. All sub-consultants will be required to conform to the QA/QC plan and provide their supplement to the plan if they are performing a specialized service that is not adequately addressed in the plan. Problem areas will be discussed with the sub-consultant and agreed upon remedial actions will be taken by the sub-consultant.

#### 10.4. SUPERVISION (27.34)

Perform all activities required to supervise and coordinate project. These activities must be performed by the project supervisor, PSM, or their delegate as approved by the DSMO.

#### 10.5. COORDINATION (27.35)

Coordinate survey activities with other disciplines. These activities must be performed by the project supervisor, PSM, or their delegate as approved by the DSMO.

# 11. FIELD PROCEDURES

#### 11.1. FIELD REVIEW (27.31)

Perform verification of the field conditions as related to the collected survey data.

#### 11.2. LINE CUTTING (27.26)

Perform all efforts required to clear vegetation from the line of sight.

See the *Survey Safety Handbook* for line cutting safety procedures.

#### 11.3. WORK ZONE SAFETY (27.27)

Work zone safety is the first consideration. Project location and scope dictate the measures needed to maintain a safe workplace. Work should not begin at the site until proper traffic control devices, e.g., signs and cones, have been placed and other safety precautions taken. Please refer to the *Manual on Uniform Traffic Control Devices (MUTCD), Part VI* for information on traffic control devices.

Appropriate MOT certification should be maintained. See *Maintenance of Traffic Training, Topic No.* 625-010-010.

Every employee should watch for hazards along the highway, and if one is noted, should act to eliminate it promptly. If it cannot be eliminated, appropriate traffic control devices should be placed to protect the public.

The *Survey Safety Handbook* outlines the Department's survey safety program, and is available through the *FDOT SMO website*. Specific attention should be paid to the placement of control to ensure that consultants, DOT employees, and the public are

protected to the greatest extent possible. The historic placement of control on or near the pavement in high traffic areas is discouraged.

# PHOTOGRAMMETRY

- 1. FLIGHT PREPARATION (28.1)
- 2. CONTROL POINT COORDINATION (28.2)
- 3. MOBILIZATION (28.3)
- 4. FLIGHT OPERATIONS (28.4)
- 5. FILM PROCESSING (28.5)
- 6. PHOTO PRODUCTS (28.6)
- 7. SCANNING (28.7)
- 8. LiDAR (28.8)
- 9. AERIAL TRIANGULATION (28.9)
- 10. SURFACES (28.10)
- 11. ORTHO GENERATION (28.11)
- 12. RECTIFIED DIGITAL IMAGERY (GEOREFERENCED) (28.12)
- 13. MOSAICKING (28.13)
- 14. SHEET CLIPPING (28.14)
- 15. TOPOGRAPHICS (3D) (28.15)
- 16. PLANIMETRICS (28.16)
- 17. DRAINAGE BASIN (28.17)
- 18. CADD EDIT (28.18)
- 19. DATA MERGING (28.19)
- 20. MISCELLANEOUS (28.20)
- 21. FIELD REVIEW (28.21)
- 22. TECHNICAL MEETINGS (28.22)
- 23. QUALITY ASSURANCE/QUALITY CONTROL (28.23)
- 24. SUPERVISION (28.24)
- 25. COORDINATION (28.25)

# **RIGHT OF WAY MAPPING**

# 1. MASTER CADD FILE

A master CADD file will be created for all right of way related maps prepared for the Department. Files will be delivered in a format that adheres to the *CADD Manual, Topic No.* 625-050-001.

Master CADD files may contain any number of the following elements as directed by the DSMO:

#### 1.1. ALIGNMENT (29.1)

The line work along with all required data will be placed in this file. Required data includes bearings on tangent lines, stationing, all curve elements and points of intersection station value with deflection angle left or right.

#### 1.2. SECTION AND QUARTER-SECTION LINES (29.2)

The line work along with all required data will be placed in this file. Required data includes labeling of bearings/distances and ties by station/distance to the survey alignment. Closure reports, if required, will be calculated from this file.

#### 1.3. SUBDIVISIONS (29.3)

The line work along with all required data will be placed in this file. Required data includes name, recording data, boundaries (with arrow indicators), lot/block lines, lot/block numbers, street names, alleys, and platted easements. Subdivisions will be tied to the survey alignment with station values. The DSMO will determine the method of ties, whether by 90 degree offsets or by straight-line extension. Closure reports for each block, if required, will be calculated from this file.

#### 1.4. EXISTING RIGHT OF WAY (29.4)

The line work for existing right of way by deed, maintenance or dedication for mainline corridor and/or side streets will be determined, verified and placed in this file. Required data includes name of the street, width (or varies) and source of creation, i.e., plat, deed, maintenance map.

#### 1.5. TOPOGRAPHY (29.5)

The topographic elements will be referenced to this file at the desired scale. Elements will be adjusted and modified as necessary. Required elements include, but are not limited to, buildings, canopies, signs, fences, groves, parking/pavement, above ground utilities, and bodies of water. Dimensional data required by the *Survey and Mapping Procedures, Topic No. 550-030-101* will be shown on the Right of Way Map Detail Sheets.

#### 1.6. PARENT TRACT PROPERTIES AND EXISTING EASEMENTS (29.6)

A title search analysis will be performed to determine the location of parent tract boundaries and existing easements. The line work will be shown and identified by the appropriate symbology, e.g., cell/block, and be placed in this file. A parcel identification number depicted in a parcel bubble will be placed and assigned in accordance with the *Right of Way Manual, Topic No.* 575-000-000.

#### 1.7. PROPOSED RIGHT OF WAY REQUIREMENTS (29.7)

The Roadway Designer or EOR will provide right of way requirements to the PSM. The EOR, in coordination with the DSMO and the Right of Way Acquisition Manager, will determine the type of interest required, i.e., fee, permanent or temporary easement, or license agreement. The line work will be placed in this file. All takes and remainders will be calculated, labeled and dimensioned with station and offsets designated at each change in direction of the right of way. Closure reports will be prepared for each take and remainder area.

#### 1.8. LIMITS OF CONSTRUCTION (29.8)

The line work will be provided by the Roadway Designer or EOR and placed in this file. Coordination with the Roadway Designer or EOR will be required to resolve problem areas. The line work will be labeled "L.O.C.". Care will be taken to ensure the limits of construction do not extend beyond the existing or proposed right of way as well as insuring the proposed right of way is supported by necessity in the construction plans. Limits of construction will be shown, at minimum, on all Federal Aid Right of Way projects.

#### 1.9. JURISDICTIONAL/AGENCY LINES (29.9)

The line work for jurisdictional wetlands, water boundaries and city/county limit lines will be placed in this file. The DSMO will determine how and when these lines or areas will be depicted on the actual right of way maps.

See **Sections 4 and 5 in the Surveying and Mapping** portion of this document for information on water boundary and jurisdictional surveys.

# 2. SHEET FILES

Sheet files will be created to form the actual control survey, right of way map, or maintenance map, in the following designations:

#### 2.1. CONTROL SURVEY

A control survey is prepared to provide horizontal position data for the support of right of way related maps.

#### 2.1.1. GENERAL MAP REQUIREMENTS

The map will depict, at a minimum, the following:

- The survey alignment with reference points
- Sufficient land line ties
- Recorded subdivisions, condominiums and cooperatives along with recording data
- A north arrow and scale of map
- County and state lines unless excepted by the DSMO
- City names with city limits unless excepted by the DSMO
- State, county, or municipal roads intersecting the survey alignment
- The bearing basis
- The source of dimensions: Field (F), Plat (P), Deed (D), Calculated (C)
- Sufficient general notes on sheet 1
- The Department standard title block
- A legend of abbreviations and symbols
- Found monumentation

#### 2.1.2. CONTROL SURVEY COVER SHEET (29.10)

The Department's approved sheet cell/block will be used in preparation of this cover sheet. The legend, general notes, location map and certifications will be placed on this sheet.

The following certification by the professional surveyor and mapper will be placed on the cover sheet:

I hereby certify this control survey was made for the purpose of surveying, referencing, describing and mapping the survey alignment, and providing horizontal position data for the support or control of right of way related maps for the transportation facility shown and depicted hereon. I further certify said survey was done under my responsible charge and is in compliance with the Standards of Practice as set forth by the Board of Professional Surveyors and Mappers in Chapter 5J-17, Florida Administrative Code pursuant to section 472.027, Florida Statutes.

This drawing, consisting of sheets \_\_\_\_\_\_ through \_\_\_\_\_, is a true, accurate and complete depiction of a field survey performed under my direction and completed on

Name Florida Professional Surveyor and Mapper No. \_\_\_\_\_ Address Date

THIS MAP AND REPORT OR COPIES THEREOF ARE NOT VALID WITHOUT THE SIGNATURE AND ORIGINAL RASIED SEAL OF A FLORIDA LICENSED SURVEYOR AND MAPPER.

#### 2.1.3. CONTROL SURVEY KEY SHEET (29.11)

This sheet(s) is derived from the master CADD file at an appropriate scale to show alignment(s), with reference points; section line ties; subdivisions, condominiums and cooperatives with recording data; and other elements, including monumentation identified as to size, type, set or found, as may be required. The relationship of the detail sheets may also be depicted on this sheet if required by the DSMO. The line work, text, etc. will be added/modified to fit the key sheet scale.

#### 2.1.4. CONTROL SURVEY DETAIL SHEET (29.12)

This sheet(s) is derived from the master CADD file at an appropriate scale to depict the field right of way survey data. The line work, text, etc. will be added/modified to fit the detail sheet scale. The DSMO will determine if detail sheets will be prepared for the entire project or if only recorded subdivisions will be shown on the detail sheets. All subdivision block lines will be tied by station and offset to the survey alignment. The DSMO will determine the method of ties, whether by 90 degree offsets or by straight-line extension.

#### 2.2. RIGHT OF WAY MAP

A right of way map is prepared when real property rights are to be acquired for a transportation facility. It will be designed to provide a high degree of uniformity and maximum readability.

At the discretion of the DSMO, a boundary survey or sketch of description, as defined in *Rule Chapter 5J-17, F.A.C.*, may be used for situations such as advance acquisition, hardship acquisition, donations, etc., in lieu of preparing a right of way map.

#### 2.2.1. GENERAL MAP REQUIREMENTS

The map will depict, at minimum, the following:

• If a control survey was not produced, all control survey elements will be a requirement of the right of way map.

See **Section 2.1 of the Right of Way Mapping** portion of this document for information on control surveys.

- The survey alignment with reference points
- Sufficient land line ties
- Recorded subdivisions, condominiums, and cooperatives, along with the recording data
- A north arrow and scale of the map
- County lines and state lines unless excepted by the DSMO
- City names with city limits unless excepted by the DSMO
- State, county, or municipal roads intersecting the survey alignment
- The existing right of way
- Existing easements with recording data.
- Right of way requirements with all data necessary to describe the parcel
- The bearing basis
- The source of dimensions: Field (F), Plat (P), Deed (D), Calculated (C)
- Sufficient general notes on sheet 1
- The Department standard title block
- The date of photography on projects using aerial photography
- Parent tracts with required geometry and boundaries labeled

- The parcel identification number shown in a parcel bubble for each acquisition. The parcel number assigned will be in accordance with the *Right of Way Manual*, *Topic No.* 575-000-000.
- Buildings, improvements and key topographic features, e.g., groves, fences, signs, bodies of water, etc. within the proposed right of way. Buildings, canopies/overhangs, and signs, etc. severed by the acquisition will be dimensioned accordingly. Buildings and improvements located within 50 feet for urban projects, or 100 feet for rural projects, outside of the proposed right of way line will be shown graphically only, unless otherwise instructed by DSMO. Buildings within 25 feet of the proposed right of way will show a distance from the nearest corner of the building to the proposed right of way line. Buildings will be labeled to show use if apparent, e.g., residential, commercial.
- Encroachments within existing right of way
- A legend of abbreviations and symbols
- A table of ownerships
- The statement: THIS MAP IS NOT A SURVEY on each sheet
- The statement: See sheet 1 for legend and general notes on each subsequent sheet
- Additional data required by FHWA on projects that have federal funding, e.g., limits of construction

#### 2.2.2. RIGHT OF WAY MAP COVER SHEET (29.13)

The Department's approved sheet cell/block will be used in preparation of this cover sheet. The legend, general notes, and location map will be placed on this sheet. On projects that do not require a cover sheet, the foregoing information may be shown on the key or detail sheet(s) as directed by the DSMO.

#### 2.2.3. RIGHT OF WAY MAP KEY SHEET (29.14)

This sheet(s) is derived from the master CADD file at an appropriate scale to show alignment(s), section ties, subdivisions, condominiums and cooperatives with recording data, large parent tracts and other elements as may be required. The relationship of the detail sheets may also be depicted on this sheet if required by the DSMO. The line work, text, etc. will be added/modified to fit the key sheet scale.

#### 2.2.4. RIGHT OF WAY MAP DETAIL SHEET (29.15)

This sheet(s) is derived from the master CADD file at an appropriate scale. The line work, text, etc. will be added/modified to fit the detail sheet scale. These detail sheets may also be copied from the existing detail sheets of the control survey. Detail sheets will include parcel numbering by use of bubbles, complete geometry for all takes and geometry for remainders as directed by the DSMO, topography, limits of construction, if required and jurisdictional or agency lines, if required.

#### 2.2.5. MAP PROCESSING

Processing will be as follows:

• The designated District authority will approve and date each map sheet.

#### 2.2.6. MAP REVISIONS

Prior to making revisions to approved right of way maps, documentation will be provided to the project file to identify:

- the person(s) requesting the change.
- the person(s) authorizing the change.
- a detailed description of necessary change(s).
- an explanation of why the changes are necessary.

#### 2.3. MAINTENANCE MAP

A maintenance map is prepared and filed with the Clerk of the Circuit Court when the DSMO has determined that there has been no formal conveyance of right of way or accepted dedication or there is notification/evidence that a formal conveyance was ineffectual to pass title to the Department.

#### 2.3.1. GENERAL MAP REQUIREMENTS

The map will depict, at minimum, the following:

- The survey alignment with reference points
- Sufficient land line ties
- A north arrow and scale of map
- County and state lines unless excepted by the DSMO
- City names with city limits unless excepted by the DSMO

- A State, county, or municipal roads intersecting the survey alignment
- The existing right of way
- The maintained right of way lines with station and offset to the survey alignment
- Key topographic features
- The bearing basis
- The source of dimensions
- Sufficient general notes on sheet 1
- The Department standard title block
- The date of photography on projects using aerial photography
- A legend of abbreviations and symbols

#### 2.3.2. MAINTENANCE MAP COVER SHEET (29.16)

The Department's approved sheet cell will be used in preparation of this cover sheet. The legend, general notes, location map and certifications will be placed on this sheet. On projects that do not require a cover sheet, the foregoing information may be shown on the key or detail sheet(s) as directed by the DSMO.

The following certifications will be placed on the cover sheet:

1. The Department certification

THIS IS TO CERTIFY that sheets numbered \_\_\_\_\_ to \_\_\_\_, inclusive, constitute a true copy of the State of Florida Department of Transportation Maintenance Map for a portion of State Road \_\_\_\_\_, designated as \_\_\_\_\_ in \_\_\_\_ County, Florida.

THE PROPERTY labeled \_\_\_\_\_\_ on said sheets has been vested in the State of Florida Department of Transportation pursuant to the provision of Section 95.361, Florida Statutes

IN WITNESS WHEREOF, we have hereunto set our hands and affixed the seal of the State of Florida Department of Transportation, at \_\_\_\_\_, Florida, this \_\_\_\_\_ day of \_\_\_\_\_, A.D. 20\_\_.

District Secretary Department of Transportation State of Florida (Witness)

#### **2.** The recording certificate

Filed for record in the office of the Clerk of the Circuit Court for the County of \_\_\_\_\_\_, State of Florida, in Road Plat Book \_\_\_\_\_, Page \_\_\_\_\_, on the \_\_\_\_\_ day of \_\_\_\_\_, A.D. 20\_\_\_.

**3.** The professional surveyor and mapper's certification

This survey was performed for the specific purpose of establishing a survey alignment and locating the limits of maintained right of way as identified by the Maintenance Engineer for the transportation facility shown and depicted hereon. I hereby certify to the best of my knowledge and belief this is a true, accurate and complete depiction of a field survey performed under my direction and completed on \_\_\_\_\_\_. I further certify that said drawing is in compliance with the Standards of Practice as set forth by the Florida Board of Professional Surveyors and Mappers, in Chapter 5J-17, Florida Administrative Code pursuant to Section 472.027, Florida Statutes.

Name Florida Professional Surveyor and Mapper No. \_\_\_\_\_ Address Date

THIS MAP AND REPORT OR COPIES THEREOF ARE NOT VALID WITHOUT THE SIGNATURE AND ORIGINAL RASIED SEAL OF A FLORIDA LICENSED SURVEYOR AND MAPPER.

**4.** If the responsible maintenance engineer or authority has not signed an affidavit, he or she must certify as follows:

This is to certify that the limits of maintained right of way as shown on this map were identified by myself as having been maintained continuously for four (4) years without interruption.

*Name and Title* Date

#### 2.3.3. MAINTENANCE MAP KEY SHEET (29.17)

This sheet(s) is derived from the master CADD file at an appropriate scale to show alignment(s), section line ties, subdivisions, condominiums and cooperatives with recording data, and other elements as may be required. The relationship of the detail sheets may also be depicted on this sheet if required by the DSMO. The line work, text, etc. will be added/modified to fit the key sheet scale.

#### 2.3.4. MAINTENANCE MAP DETAIL SHEET (29.18)

This sheet(s) is derived from the master CADD file at an appropriate scale. The line work, text, etc. will be added/modified to fit the detail sheet scale. These detail sheets may also be copied from the existing detail sheets from the right of way control survey. All maintained right of way along the mainline corridor will be supported by certified field notes. At the direction of the DSMO, reference to the appropriate field books will be made either in the general notes on the cover sheet or by reference on the detail sheet. Station and offsets will be shown at each change in direction of the right of way.

#### 2.3.5. MAP PROCESSING

Processing will be as follows:

- After the map has been accepted by the DSMO, the original and 1 set of prints will be submitted to the appropriate authorities for certification and witnessing.
- After the map has been certified and witnessed, the DSMO will obtain 1 film copy and file the original map with the Clerk of the Circuit Court. The Clerk will affix the recording information on the set of prints for DSMO records and the recording data will be placed on the film copy retained by the DSMO.

#### 2.4. REFERENCE POINT SHEET SET (29.19)

This information as derived from field book data or electronic files will be plotted into a CADD file. The line work, text, etc. will be added/modified to fit the sheet scale, if applicable. There will be a maximum number of 15 reference points per sheet. Reference point sheets will be prepared at the direction of the DSMO as appropriate to the project. This sheet(s) will be included with the control survey, right of way map, and maintenance map.

#### 2.5. PROJECT NETWORK CONTROL SHEET (29.20)

This information as derived from field book data or electronic files will be plotted into a CADD file. The line work, text, etc. will be added/modified to fit the sheet scale, if applicable. Project network control sheet(s) will be prepared at the direction of the DSMO as appropriate to the project.

This sheet depicts the baseline, benchmarks, primary and secondary control points and their reference points including the type of material used for each point, their X,Y,Z

coordinates, scale factors and convergence angles. This sheet(s) may be included with the control survey map, right of way map, and maintenance map.

#### 2.6. TABLE OF OWNERSHIPS SHEET (29.21)

The Department's approved sheet cell will be used in preparation of the ownerships sheet. Required data will include parcel number, sheet numbers on which the parcel appears, name of property owner(s), the area in square feet or acres of the part to be acquired and the remainder (when there is no remainder show 0), any necessary comments, and the recording data of the executed or condemned parcel when completed.

# 3. MISCELLANEOUS SURVEYS AND SKETCHES

#### 3.1. PARCEL SKETCHES (29.22)

Parcel sketches may be prepared for various purposes at the direction of the DSMO. Purpose, format, scale, etc. are designated in the scope as required.

#### 3.2. TIITF SKETCHES (29.23)

Sketches are prepared for the Department to obtain rights over sovereignty submerged lands or state owned uplands. Specific requirements, e.g., purpose, format, scale, are designated in the scope or by the requirements of FDEP, BSM.

#### 3.3. OTHER SPECIFIC PURPOSE SURVEYS (29.24)

These may include preparation of maps for mitigation surveys or jurisdiction line surveys. Specific requirements, e.g., purpose, format, scale, are designated in the scope.

#### 3.4. BOUNDARY SURVEY MAP (29.25)

This survey may be prepared for any specific need at the direction of the DSMO. Specific requirements, e.g., purpose, format, scale, are designated in the scope.

#### 3.5. RIGHT OF WAY MONUMENTATION MAP (29.26)

This survey is prepared for the depiction of the field-monumented right of way. The right of way map set is the basis for this map with minimal adjustments to the cover sheet, including adding the proper certification. The recording data is shown on the table of ownerships sheet. It is prepared and filed after the right of way has been monumented.

#### 3.5.1. ADDITIONS TO THE RIGHT OF WAY MAP

The following will be added to the original right of way map:

• The appropriate symbol where each right of way monument was set

- A note on each map sheet describing the symbol indicating the right of way monument
- The recording data for each parcel acquisition or condemnation in the table of ownerships

#### 3.5.2. CERTIFICATIONS

A reproducible copy of the original right of way map that meets the requirements of the appropriate Clerk of Circuit Court will be made after the above is completed and the title blocks will be revised to show *RIGHT OF WAY MONUMENTATION MAP*. The note *THIS MAP IS NOT A SURVEY* will be removed from all sheets of the reproducible copy and the following will be added.

The certificate of the PSM in responsible charge on sheet 1 as follows:

This certification is made exclusively to the Florida Department of Transportation.

This survey was performed for the specific purpose of monumenting the existing right of way only for the transportation facility shown hereon. I hereby certify that to the best of my knowledge and belief, the right of way monumentation as shown by the symbol for Permanent Right of Way Markers (P.R/W M.) and depicted on this drawing, consisting of sheets \_\_\_\_\_\_\_, is a true, accurate, and complete depiction of a field survey performed under my direction and completed on \_\_\_\_\_\_. I further certify that said drawing is in compliance with the Standards of Practice as set forth by the Florida Board of Professional Surveyors and Mappers, in Chapter 5J-17, Florida Administrative Code pursuant to Section 472.027, Florida Statutes.

Name of Surveyor Florida Professional Surveyor and Mapper No. \_\_\_\_\_ Address Date

THIS MAP AND REPORT OR COPIES THEREOF ARE NOT VALID WITHOUT THE SIGNATURE AND ORIGINAL RASIED SEAL OF A FLORIDA LICENSED SURVEYOR AND MAPPER.

The recording certificate on sheet 1 as follows:

Filed for record in t	he office of the Clerk of t	he Circuit Court for	the County of	,
State of Florida, in	Road Plat Book	, Page	, on the	
day of	_, A.D. 20			

#### 4. MAP PREPARATION

#### 4.1. SIZE & FORMAT

All final right of way related map sheets will be a size which is determined by the DSMO to be acceptable to the Clerk of the Circuit Court for recording.

All sheet formats will have a standard title block with provision for a federal project number.

All final right of way maps prepared for the Department are to be delivered in hard copy and/or electronic format that adheres to the *CADD Manual, Topic No.* 625-050-001.

#### 4.2. MATERIAL

The map material for all final right of way related map sheets delivered in hard copy will be submitted on a reproducible material that meets the requirements of both the DSMO and the Clerk of the Circuit Court.

# 5. TITLE SEARCH AND DOCUMENT PREPARATION (29.28)

The procurement of lands for transportation facilities requires a current report of the present ownership and all encumbrances on each parcel to be acquired. This includes, within the report, a list of all conveyances of the subject land made during the most recent five year period together with the consideration paid based on documentary stamps. Title search reports are prepared in accordance with the *Right of Way Manual, Topic No. 575-000-000* and based upon a thorough search of the public records, which may require searching back to the earliest public records. The services of a qualified title company or title examiner are usually obtained for this purpose. In Districts where the Department has qualified personnel experienced in title examination, the DSMO may elect to obtain its own updates and to do some or all original title searches.

Information received from title searches is analyzed by surveying and mapping personnel in order to make property boundary determinations necessary for adequate map and document preparation. Specifically, the descriptions of the various ownerships are plotted to scale for inclusion on the maps. In addition, a determination of the various encumbrances such as mortgages, liens, easements, etc., of record against each parcel are identified based upon the report of title search. In some instances the assistance of the District general counsel and/or the Department's general counsel may be required for specific interpretations.

Documents of conveyance are prepared in accordance with the *Right of Way Manual, Topic No. 575-000-000.* 

#### 5.1. TITLE SEARCH MAP (29.27)

This map is prepared utilizing property appraiser maps or preliminary right of way maps. The purpose of this map is to depict the properties affected by the proposed project requirements. This map is used to obtain title search reports necessary to develop the right of way maps. The DSMO directs the schedule of preparation.

#### 5.2. RIGHT OF WAY MAPPING RESPONSIBILITIES

Obtaining, analyzing and processing current title search and updates is the responsibility of the DSMO under direction of the District General Counsel until delivery of the right of way project to the Office of Right of Way. Title search reports/updates are certified to within six months of delivery of the project to the Office of Right of Way. After the project is delivered the responsibility for updating title is determined by the District.

Title search reports reflect all documents that create, or purport to create, an interest, lien or encumbrance in the parcel. Title searches should cover a sufficient period of time to include any existing easements or reservations. A description of all conveyances that occurred in the five years immediately preceding the completion date of the title search is also included.

On all title search contracts for the Department, the DSMO serves as contract manager and has the following responsibilities:

- Enforcement of performance of all contract terms and conditions
- Liaison between the Department and the title examiner

#### 5.3. ORDERING A TITLE SEARCH

The contract manager furnishes the title company or title examiner with a copy of the title search map. Occasionally, the title examiner may find a reference to plats and subdivisions that have not been depicted on the preliminary maps or property appraiser maps. In such cases, he includes a copy of the plats with the title search so that the maps can be corrected. When the maps are submitted to the title company or title examiner, the contract manager may include an estimate on time of completion and an authorized expenditure with the letter of authorization for the title examiner or title company to commence work on the project.

The letter of authorization to the title company or title examiner may also provide the following:

- Reference to the title search agreement under which the search is being ordered, and the amounts quoted for the various types of search under the agreement
- The number of copies of the search to be furnished as required by the contract manager

• A tentative due date for the search

#### 5.4. CERTIFICATION OF UPDATE

The title examiner, under the provisions of the title search contract agreement, is required to certify any update of the original search. The update shows the owner's name and mailing address. The title examiner also provides specific data as to outstanding encumbrances not already listed in previous title searches, such as mortgages (with book and page reference) and satisfaction of mortgages (with book and page reference).

# 6. LEGAL DESCRIPTIONS (29.29)

#### 6.1. MINIMUM REQUIREMENTS

All points of commencement, where practical, should be outside of the required right of way. Descriptions must also be prepared and certified in accordance with the *Surveying and Mapping Procedures, Topic No. 550-030-101*. The format will be determined by the DSMO.

#### 6.2. INFORMATION FOR WRITING LEGAL DESCRIPTIONS

- A set of right of way maps that show the required right of way with all necessary geometry.
- Title information from the most recent title search, including any updates. This information should include the current record owner, the legal description of the property, and a list of all encumbrances on the property. Easement locations must be plotted to determine whether they will affect the right of way taking. Determination may then be made to ascertain if the taking will be subject to an existing easement, subordinated or fully cleared. Private easements may be brought to the attention of the DSMO by title examiners, surveyors, appraisers, and others. This information must also be included on the right of way maps.
- Other information may be obtained from additional field survey, local surveyors, or other sources to clarify the property boundary location and title data. On consultant prepared projects, the consultant will coordinate this effort with the DSMO.

#### 6.3. EARLY INVOLVMENT IN MAP PREPARATION

- Includes analyzing the title search to define parent tracts and ownerships affected by the proposed right of way acquisition.
- Includes reviewing the title search for errors in the legal description or omissions in the title evidence. Items requiring clarification must be referred promptly to the

title examiner or title company to complete the title work before the preparation of legal descriptions. Title updates may indicate revisions for which the maps should be adjusted.

• The record parent tract legal description for each right of way parcel and the proposed right of way requirements will be depicted as required on the right of way map and assigned a numbered parcel bubble in accordance with Section 6.4 of the Right of Way Mapping section of the handbook.

#### 6.4. ASSIGNMENT OF PARCEL NUMBERS

Parcel numbers are assigned conforming to the numbering convention as follows:

- Series 1 99 is reserved.
- Series 100 699 is used for all parcels to be acquired in fee.
- Series 700 799 is used for temporary easements.
- Series 800-899 is used for perpetual easements, including TIITF parcels.
- Series 900 999 is used for all license agreements.

In the event any series exceeds the above range on a project, the series is extended by beginning with the first number of that series and adding 1000. For example, 100-699 would become 1100-1699, etc.

Once a parcel number is assigned and transmitted to the Office of Right of Way it may not be reused or reactivated if voided.

#### 6.5. VESTING OF TITLE TO ROADS

When a state road intersects a street or dedicated right of way owned by a local governmental agency, that portion of the right of way that is required for maintenance of the state road after construction should be clearly depicted on the right of way map. If legal descriptions are required, they are prepared at the direction of the DSMO in accordance with local agency requirements. If necessary, a parcel number(s) may be assigned.

#### 6.6. PREPARATION OF LEGAL DESCRIPTIONS

Having completed the analysis of the title evidence, plotting of ownerships, reconciling conflicting information, and showing the information on the right of way map, including

right of way requirements, the legal descriptions can be prepared. The DSMO will determine the description format.

All data, distances and bearings used in a legal description should be readily discernible from the right of way map, with all data between the map and the legal description in complete agreement.

Computations and closure reports are prepared to support the description and provide additional data that may be required on the right of way map.

#### 6.6.1. BASIC METHODS

The basic methods to be used for the description of real property are:

- Metes and bounds
- Survey alignment description
- Sections, lots, blocks or specific parts thereof

#### 6.6.2. AREA

Areas are shown in all legal descriptions in square feet or acres, usually not both. The areas agree with the table of ownership sheet and depicted as follows:

- Areas of a half-acre or more should be shown in acres, to 3 decimal places. Areas less than a half-acre should be shown in square feet, to the nearest foot, or as directed by the DSMO. Areas, both acres and square feet, should be followed by *more or less.*
- For legal descriptions with multiple parts where some of the parts are less than or equal to 1/2 acre but the total amounts to more than 1/2 acre, the parts may be shown to the nearest square foot following each part of the legal description and the total in acres at the end of the legal descriptions. Parts should be clearly tied together by "AND" or "ALSO" to clearly show the intent. Care should be taken to ensure that the "part" areas add up to the total area with no rounding differences, and there are no discrepancies with the table of ownership sheet. The DSMO directs the method of depiction on the table of ownership sheet, i.e., total area only or parts shown.

#### 6.6.3. METES AND BOUNDS DESCRIPTIONS

This type of description is one which requires adequate field survey information to identify the point of beginning and list the bearings and distances that define the limits of the parcel. This is the preferred method if a simpler description is not suitable.

Each metes and bounds description should adequately identify the land described and make the title certain with regard to adjoining ownerships by the use of proper qualifying language.

#### 6.6.3.1. PARENT TRACT

In some instances minor flaws may be detected in the parent tract description that would not materially affect the right of way. In such instances, the parent tract should be placed in direct quotes to indicate the description of the parent tract is being used exactly as the conveyance was made to the current owner.

However, when major discrepancies are detected such as improper sections, townships or ranges that would place the property a considerable distance from the actual location on the ground, the property owner should be advised of the discrepancy and should file a corrective deed before the Department takes title. In the event this cannot be accomplished, an alternate method for describing the right of way should be pursued such as by direct metes and bounds or survey alignment description.

#### 6.6.3.2. EXCEPTIONS TO THE PARENT TRACT

Occasionally, a parent tract description contains one or more areas that are excepted from it. These may be described by copying the parent tract description and following it by the description of the exception, clearly denoting it as an exception.

#### 6.6.4. SURVEY ALIGNMENT DESCRIPTION

Where partial takings of a generally constant width are involved throughout a considerable length of the project, the survey alignment description is often the most practical type of description. This description is based upon right of way taking of a portion of land out of a given parent tract that lies within a specific distance of a survey alignment.

#### 6.6.4.1. SURVEY ALIGNMENT TIES

This line may be a survey alignment or a construction centerline tied at both ends to known land corners such as a section corner, quarter section corner, subdivision block corner or permanent reference monument. The distance between ties should not normally exceed one mile except through large acreage tracts where it is permissible to cover the entire tract without intermediate ties. When crossing large acreage tracts, a beginning tie to a substantial corner prior to reaching the large tract is required. List the sections that are being crossed and tie to a substantial corner or just past the ending boundary line for the tract.

#### 6.6.4.2. SURVEY ALIGNMENT CURVES

Describe by curve data, tangent lengths, and bearings, the survey alignment used in the description.

The description of the curve should contain the following information:

- concave direction
- direction of curve
- central angle
- length
- radius

If the curve is non-tangent, additional information to define the curve will be included.

A survey alignment beginning on a curve will have the tangent bearing or chord bearing at the beginning indicated and the curve data should define only that part of the curve included in the description.

#### 6.6.4.3. SURVEY ALIGNMENT IDENTIFICATION

The survey alignment, centerline, and construction centerline may or may not be common lines, so it is important that the line on which the right of way is based be clearly identified in the description and on the right of way map. Survey alignments should be described as beginning and ending on a land line, with a bearing and distance to the nearest land corner. It is most important the bearing of the land line be shown in order to have complete ties.

Many variations of the survey alignment description are used, but the principle remains the same. Each line is identified by name such as baseline, centerline, survey alignment, etc. as shown on the maps.

In most cases, especially where the width of the right of way varies, direct metes and bounds is the best method to describe real property.

#### 6.6.4.4. RIGHT OF WAY WIDTH

After defining the survey alignment, then define the width of the taking. The right of way map indicates the required width.

Where there is existing right of way, it should be clearly stated in the description, e.g., *excepting 25 feet of existing right of way on each side of the survey alignment...*, and the area for the taking should also exclude the area of the existing right of way.

#### 6.6.4.5. VARIABLE WIDTH RIGHT OF WAY

Occasionally, a description requires a change of right of way width within the parcel. This change may be defined by station and offset located in the description of the survey alignment that follows.

Breaks can be located on property lines, instead of station numbers. Occasionally, a transition in the right of way may be needed.

#### 6.6.4.6. DESCRIPTIONS FOR FEDERAL LAND TRANSFERS

Where survey alignment descriptions are utilized to describe parcels for federal land transfers where the taking is uniform throughout, recite the beginning and ending stations where the survey alignment enters and leaves the federal lands.

In most cases, especially where the width of the right of way varies, direct metes and bounds is the best method to describe federal lands.

#### 6.6.5. WHOLE AND PARTIAL TAKINGS

#### 6.6.5.1. WHOLE TAKING

An entire ownership as described in the title evidence may be used if all the land is acquired and the description is correct in all respects.

#### 6.6.5.2. PARTIAL TAKING

Partial takings may be defined in various ways; however, the intent should be clear.

These various ways are:

- By recited dimension in a designated direction, sometimes called a strip description.
- By area, specified or proportionate
- By exception of portion not conveyed
- By division line between parcels

Care should be exercised in describing partial takings, especially with parcels that do not lie in cardinal directions, and those with irregular shapes.

#### 6.6.5.3. SECTIONAL DESCRIPTIONS

Surveyors should follow best practices for referencing lands defined by the Public Land Survey System as defined by the *Manual of Survey Instructions for the Survey of the Public Lands of the United States, 2009.* 

#### 6.7. MULTIPLE DESCRIPTIONS, LIMITED ACCESS & FREE ACCESS

A description may consist of more than one area of land to be included in the parcel. It is most important the descriptions of these parts be tied together by "AND" or "ALSO" in order to clearly show the intent. Care should be exercised to ensure the separate parts do not overlap as this can cause confusion as to the intent and possible duplication of acreage.

Locations where access rights are acquired must be defined and clearly separated from free access and other interest included in the same document. Limited access takings must include the following language: "Together with all rights of ingress, egress, light, air and view between the above described property and the Grantor's remaining property.

#### 6.8. EASEMENTS

#### 6.8.1. TEMPORARY EASEMENTS

A time limit is used on temporary easements for stockpiles, detours, construction easements, and other easements required during the period of construction. These time limits run from the date of execution of the instrument unless otherwise noted.

#### 6.8.2. PERPETUAL EASEMENTS

Perpetual easements are generally used for drainage outfalls, drainage inlets, slopes, wall maintenance, ingress/egress and other easements that need to be permanent.

#### 6.9. VERIFICATION

Verification of all descriptions, original or revised, will be included as part of the QA/QC plan.

#### 6.10. CERTIFICATION

The description for each parcel must be certified, i.e., signed, sealed, and dated, by a professional surveyor and mapper as meeting the *Standards of Practice* pursuant to *Section 472.027, F.S*, and must also be prepared in accordance with the *Surveying and Mapping Procedures, Topic No. 550-030-101*.

Unless each description is certified individually, the professional surveyor and mapper will prepare a certification letter as follows:

I hereby certify that, to the best of my knowledge and belief, the attached legal descriptions of parcels \_\_\_\_\_as shown on the right of way maps designated as \_\_\_\_\_are true, accurate, and were prepared under my direction.

I further certify that said legal descriptions are in compliance with the Standards of Practice as set forth by the Florida Board of Professional Surveyors and Mappers in Chapter 5J-17, F.A.C., pursuant to Section 472.027, F.S.

Name of Surveyor Florida Professional Surveyor and Mapper No. \_\_\_\_\_ Address

Date

THIS MAP AND REPORT OR COPIES THEREOF ARE NOT VALID WITHOUT THE SIGNATURE AND ORIGINAL RASIED SEAL OF A FLORIDA LICENSED SURVEYOR AND MAPPER.

# 7. MISCELLANEOUS

#### 7.1. ROAD TRANSFERS

After notice has been given, pursuant to *Transportation System Jurisdiction and Numbering, Topic No. 525-020-010*, that a state road has changed jurisdictional classification, the orderly transfer of rights of way by deed or the filing of a right of way map must be initiated. The use of right of way maps is the preferred method. Below is the certificate to be used.

This right of way map, when recorded, is an instrument of conveyance, transferring in accordance with Section 337.29(3), F.S., all right, title and interest of the Florida Department of Transportation in the road, street, highway, set forth on this map to\_\_\_\_\_ County.

Recorded in Public Records of	County	, Florida, this_	day of
, A.D. 20	, in Road Plat Book	, Page	

Clerk of the Circuit Court County. Florida

# 8. OFFICE PROCEDURES

#### 8.1. TECHNICAL MEETINGS (29.32)

Attend meetings as required and negotiated by the DSMO.

#### 8.2. QUALITY ASSURANCE/QUALITY CONTROL (29.33)

See **Section 10.3 of the Surveying and Mapping** section of this document for information on the QA/QC Plan.

#### 8.3. SUPERVISION (29.34)

Perform all activities required to supervise and coordinate project. These activities must be performed by the project supervisor, PSM, or their delegate as approved by the DSMO.

#### 8.4. COORDINATION (29.35)

Coordinate survey activities with other disciplines. These activities must be performed by the project supervisor, PSM, or their delegate as approved by the DSMO.

#### 8.5. SUPPLEMENTAL MAPPING (29.36)

This task is to cover efforts resulting from major design and/or development changes after 60% map development that affect the right of way requirements/parent tract property lines and may include any number of tasks. Request and approval to utilize the supplemental mapping hours will be in writing and approved by the DSMO prior to any work being done under this task.

#### 8.6. FINAL MAP/PLANS COMPARISON (29.30)

The PSM will perform a comparison of the final right of way maps, with the available construction plans, to review the correctness of the type of parcel to be acquired and the stations/offsets to the required right of way. The PSM will coordinate with the EOR to resolve any conflicts or discrepancies and provide documentation of the review.

# 9. FIELD PROCEDURES

#### 9.1. FIELD REVIEWS

Perform verification of the field conditions as related to the survey data.

# **TERRESTRIAL MOBILE LIDAR**

# APPENDIX A NOTES, DATA COLLECTION, AND DATA PROCESSING

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# 1. NOTES AND NOTEKEEPING

Whether recorded electronically or by hand, field notes may be used by persons who are not familiar with the area, and who must rely on what is recorded in the notes. For this reason, the notes must contain all necessary information and they must be recorded in a form that will allow for easy interpretation. All field notes must be recorded in the field. Sketches may be invaluable in clarifying electronically collected data.

The current practice for the Department is to collect survey data electronically. Topography, cross-section, terrain, and other similar data can be collected and stored this way. After processing and field verification, the database is exported to Department approved design software.

The method of collecting data should be reviewed with the Department before the project is begun to assure compatibility of the digital data with Department approved formats, notation and other essentials.

Electronic data may be supplemented by notes and sketches in traditional, bound field books. If field books are submitted as part of the survey record, the following guidelines apply:

- On the front cover of each field book, indicate in ink: the project number, the county in which the survey is made, and the contents of the book, e.g. *Bench Levels and Cross Sections*. On the back edge, in ink, indicate the book number and project number. See *Figure 1* below.
- Sample field book certification. See *Figure 2* below.
- Pages will not be removed from a field book. Incorrect or obsolete notes should be marked *VOID*, dated, and initialed. Numerical data will not be erased. If a number is in error, a single line should be drawn through it, and the correct number written above.
- On the inside fly sheet of each standard bound field book will be a pre-stamped form with the book number and spaces for other essential identification information which the user is required to fill in, including the job description exactly as it appears in the Department's Financial Management System. See *Figure 1* below.
- The next page after the identification information will be page 1. To assure adequate space, pages 1-5 should be reserved for indexing and other information. The numbering of the pages is continued from page 1 throughout the field book, numbering the upper right hand page only.
- Cross reference all incomplete items when revisions or continuations are made. Make all subsequent corrections and additions to notes in red.

• At the completion of the survey, all field books containing data for the project will be collected, organized and delivered to the DSMO.

FIELD BOOK COVER	INSIDE COVER	
197500         F.P.I.D.           18210         F.P.I.D.           SEC. NO.         STATE RD.           STATE RD.         COUNTY           BOOK NO.         CONTENTS           BK         CONTENTS	BOOK NO	
CERTIFICATION		
I hereby certify that as of the date shown below, all data recorded in field book numberis a true representation of the field survey made under my responsible charge and that to the best of my knowledge said field survey is in compliance with the Standards of Practice adopted by the Florida Department of Agriculture and Consumer Services, Board of Professional Surveyors and Mappers.		
CERTIFIED		
Print Name		
Florida Professional Surveyor and Mapper No.		
Page(s)	Date	

FIGURE 2

#### 1.1. CERTIFIED FIELD BOOK

A certified field book may be kept to record the following information:

- Baseline alignment and references
- Bench levels and bench mark index
- DTM check cross sections

#### 1.2. FIELD WORK BOOK

A segment/project field work book may be kept to record the following information. This information includes but is not limited to the following:

- Project network control, DTM survey, R/W control survey axis test repetitions, network/traverse repetitions, and control point index/references
- Height of instrument and height of target for each setup
- A sketch of the topography chains, including DTM break line chains, with labels and pertinent point names to store the chains
- A list of chains containing chain point lists as an aid in the chain revision during post processing
- Notes to aid in post processing such as modifications to a series of points

# 2. ELECTRONIC SURVEY DATA COLLECTION

Electronic survey data collection applies to all methods of field survey that utilize electronic means to take measurements relating to land information, including storing, analyzing, processing, and archiving of that information. This commonly involves the use of GPS, total stations, data collectors, and software such as, but not limited to, EFB, CEFB, CAiCE, GEOPAK, VectorNT, MicroStation, and Civil 3D.

#### 2.1. CALIBRATION

Axis tests will be performed when using total stations, as defined in the *EFB User Handbook*. The *EFB User Handbook* is available for download in portable document format (.pdf) within the file *EFB.ZIP* at:

http://www.dot.state.fl.us/surveyingandmapping/doc\_pubs.shtm

#### 2.2. CONTROL CHECK-IN

Control should be re-observed in direct and reverse telescope, recording horizontal angle, zenith angle, and slope distance as a check. To ensure that the setup is not disturbed, checking into the control must be done at a minimum of the beginning and end of each setup, but may need to be done more frequently in high risk areas.

#### 2.3. ELECTRONIC MEASUREMENT METHODS

TOPOGRAPHY, DTM, AND R/W CONTROL SURVEY DATARight of way control surveys may be collected in HVD or HD mode.

#### 2.3.1. HD MODE

Mode of measurement, normally with a total station, in which the horizontal circle reading (H) and the horizontal distance (HD) are recorded. Height of instrument, unnecessary for producing the horizontal position of the setup point, is still measured and recorded in case more than one measurement mode is used on a particular setup. Height of target is not measured and is not used in the processing.

#### 2.3.2. HVD MODE

Mode of measurement, normally with a total station, in which the horizontal circle reading (H), the zenith circle reading (V), and the slope distance (D) are recorded. Horizontal angles are measured clockwise to the right. Zenith angles are measured from the zenith at zero degrees. Height of instrument (HI) and the height of the target (HT) are also measured and recorded. These measurements combine to process the horizontal and vertical position of a point or a series of points.

#### 2.3.2.1. HVD OBSERAVTIONS

Refer to the *EFB User's Handbook* for feature coding and attributing of points and chains.

#### 2.3.3. SOR MODE

Mode of measurement, normally with a level, level rod, and tape, in which an alignment station value (S), offset right or left of the alignment (O), and the level rod reading (R) are recorded. The horizontal and vertical position of a point or a series of points is processed based on the alignment position and a controlling elevation.

#### 2.3.3.1. SOR OBSERVATIONS

Setup the level and record an observation to a BM or TBM. Measure and record the required offsets and the corresponding level rod readings.

SOR observations are useful when locating topographic features and taking traditional cross-sections on small special purpose projects and on resurface projects where large cross-section intervals are employed and a DTM will not be computed.

# 3. TOPOGRAPHY

3.1. All topographic features such as roadbeds, asphalt aprons, curbs and gutters, utility poles, trees, etc. should be observed in HVD mode. All points and chains relating to the ground surface model have a ground (*G*) attribute. Only those points and chains on the ground surface are used in computing the DTM. Topography and DTM surveys should be performed in HVD or SOR mode. Horizontal angle, zenith angle, slope distance (HVD) observations should not be made for distances greater than 500 feet to ensure accurate trigonometric elevations.CHAINS

A chain is the ordered connection of points that define the boundary of an object. The first step in collecting DTM data is locating all ground topographic chains. This is accomplished by radially observing all points along each chain (see *Ground Points 3.2.1*. below). Each point along a specific chain is observed, recording the horizontal and vertical position. These points are the horizontal and vertical breaks along the chain and contain point (P) geometry or curve (C) geometry.

#### 3.1.1. GROUND

Ground survey chains are all those break lines, as defined above, that lie on the ground surface. Ground chains are the profiles along the distinct breaks in the ground surface model. Ground chains will contain only ground points.

#### 3.1.2. BREAK LINES

A break line is a profile line along a distinct topographic feature or along a distinct interruption in the continuity of the ground surface. The ground topographic chains are 3-D break lines for the DTM. Some examples include roadbeds, curbs and gutters, sidewalks, shoulders, tops of endwalls, tops of slopes, ditch bottoms, etc.

#### 3.2. POINTS

#### 3.2.1. GROUND

Ground points are all those X, Y, Z positions that lie on the ground surface. Ground points include ground chain points as well as random ground positions needed to accurately generate a DTM. Once the chain points have been recorded, the random ground points are observed.

#### 3.2.2. FEATURE

Feature survey points are those X, Y, Z positions that will not be used in the DTM generation. An example is a fire hydrant located by placing the target rod on top of the hydrant. The elevation of this point will not be used when computing the DTM although its elevation is determined during post processing.

#### 3.2.3. SPOT ELEVATIONS

Spot elevations are the random ground surface observations needed to fill the remaining areas not covered by the ground chains. These observations should be made at the high and low points in the remaining areas. Spot elevations are critical in the generation of an accurate DTM. The location of these points is left to the judgment of the PSM in responsible charge based on the project requirements of the existing ground surface, and on knowledge of the data collection/DTM system.

#### 3.3. CHECK CROSS-SECTIONS

To ensure an accurate DTM, independent check cross-sections should be taken. These check cross-sections may be recorded in the certified field book and may also be recorded electronically using HVD mode or SOR mode. For further instructions, see the *EFB User's Handbook*. The surveyor in responsible charge should meet with the district survey department to set check cross-section requirements.

#### 4. SEGMENTING

Survey projects involve many points, chains, etc. To keep the data set manageable, the project is divided into segments.

Segmenting can occur in the field by one of two methods. One is to collect the data on a computer in which the segmenting is accomplished directly on the pc. The second method involves seeding the segment forward from the EFB file menu. Now two segments exist on the data collector, the previously collected segment and the newly created segment. By seeding the segment forward, the project names and chain names are copying from the previous segment over to the new segment. This resolves the segmenting issue and activates the data collection program to begin data collection in the new segment.

When creating and switching between various segments, avoid point naming conflicts. One method to avoid point naming conflicts on large projects employing multiple crews is to use a suitable crew designation, e.g., the party chief's initials, as a prefix to the segment names, point names, and chain names. If a crew is assigned a different project, end the segment by checking into control and downloading and archiving the partial segment. Download each crew's data at least daily.

# 5. DATA PROCESSING

Processing begins with downloading the segment data files to a computer and backing up the files. The data should be downloaded to a separate directory and archived unedited. Copy the files to the working directory for processing. The EFB field files are as follows:

• *filename.SDF* – Database format observation file containing all the recorded data in the segment.

The binary observation file, *filename.SDF*, is translated to an ASCII file, *filename.OBS*. A control file, *filename.CTL*, is created and these two files are used to process the survey data. Revisions are made and documented in *filename.OBS* and when this file is correct, a least squares adjustment is performed. Revisions are documented in *filename.OBS* by adding remark records at the corresponding revisions. This procedure ensures an electronic audit trail for quality control. The final result of the least squares adjustment is *filename.XYZ*. This ASCII file contains *X*, *Y*,*Z* coordinates and all the pertinent attribute data for each point in the segment. The results of the SOR observations are stored in the .SDF file. For a more detailed discussion of processing EFB data, see the *EFB User's Handbook*, the *EFB Processing System Handbook*, and the *EFB Processing System Handbook* – *Technical Reference*.

The *filename.XYZ* file is then imported or merged into a coordinate geometry database imported into the database. The project alignment and other important alignments are computed and/or stored in the database. SOR data is imported into the database after the proper alignments are stored.

#### 6. GRAPHICAL ANALYSIS

The DTM breaklines are analyzed and edited to ensure accuracy. The survey chains with ground (G) attributes are DTM breaklines. Intersecting breaklines must have a common point. Other things to look for during survey chain edits are proper attributes, proper chain lists, and proper orientation.

The data should be viewed in 3D to confirm that the survey chains are oriented correctly in the vertical plane. For example, a vertical spike in an edge of pavement chain will not be apparent in plan view. If apparent discrepancies are noted, the project should be referred back to the person in responsible charge for further action.

Once the survey chains have been verified and the DTM database has been created, the DTM triangles should be computed and then verified. The most common method of DTM verification is by comparing the computed cross-sections with the check cross-sections. Discrepancies must be investigated and corrected.

# 7. QUALITY CONTROL

See **Section 10.3 of the Surveying and Mapping** portion of this document for information on the QA/QC Plan.

#### 8. DELIVERABLES

Specific deliverables are defined in the scope. In general, the deliverables may include:

• The raw, unedited field data files

After completion of the work, all files are transferred to the Department with an itemized transmittal letter. No project will be considered complete until all deliverables are received and approved by the DSMO.

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# 1. TYPES OF GPS SURVEYS

- **Static GPS (SGPS)** Carrier phase differencing technique where the integer ambiguities are resolved from an extended observation period through a change in satellite geometry.
- **Rapid Static GPS (RSGPS)** Requires shorter occupation times than static positioning and may use a radial baseline technique, network technique, or a combination of the two.
- **Real-Time GPS (RT)** Uses measurements of the phase of the signal's carrier wave, rather than the information content of the signal, and relies on a single reference station to provide real-time corrections.
- **Real-Time Network GPS (RTN)** A variation of RT GPS surveying. Rather than setting up a base station on the project, a number of permanent and continuously operating base stations are set up providing the augmentation to the basic position as determined at the rover.

# 2. NETWORK DESIGN PLAN

Every project that uses GPS technology will have an NDP submitted and approved by the Department prior to the commencement of work.

#### 2.1. **REQUIREMENTS**

- Every NDP will include:
  - the type(s) of GPS surveys proposed.
  - the layout of the network geometry submitted in .pdf or other Department approved format.
  - the defined RT or RTN GPS survey areas, if any.
  - the control monumentation data sheets for existing control stations to be utilized.
  - the datums for all GPS surveys.
  - the identification, i.e., brand and model of equipment to be used.

# 3. EXISTING CONTROL

Constrain every PNC survey to Department approved control.

#### 4. GPS EQUIPMENT

Equipment for all GPS survey activities will be multi-frequency, survey grade, carrier phase, geodetic receivers and antennas unless prior written approval is obtained from the Department.

# 5. PRECISION AND ACCURACY

Precision and accuracy requirements are project and survey type specific. See specific survey types for precision and accuracy requirements.

Use the current Department approved network adjustment for the final adjustment. All vectors used in the adjustment will be independent vectors.

#### 6. SGPS SURVEYS

#### 6.1. OBSERVATIONS

- Vector 1 hour minimum
- OPUS 2 hour minimum

#### 6.2. DELIVERABLES

Raw data file converted to RINEX, open source, or Department approved format and delivered in electronic form for each session.

#### 6.2.1. SURVEYOR'S REPORT

- If establishing control and using OPUS as the final adjustment software, a least squares network solution must be supplied.
- If establishing control and using Vector as the final adjustment software, all input, output, and point tolerance ASCII files must be provided.
- If localizing, a transformation report must be supplied.

#### 6.3. PRECISION AND ACCURACY REQUIREMENTS

- Accuracy 0.015 ft. horizontal, 0.025 ft. vertical to base
- Occupation 2 observations, 4 hour differential
- PDOP less than or equal to 5
- Satellites 5 or more

# 7. RSGPS SURVEYS

#### 7.1. OBSERVATIONS

- Vector 30 minute minimum
- OPUS-RS 30 minute minimum

#### 7.2. DELIVERABLES

Raw data file converted to RINEX, open source, or other Department approved format and delivered in electronic form for each session.

#### 7.2.1. SURVEYOR'S REPORT

- If establishing control and using OPUS-RS as the final adjustment software, a least squares network solution report must be supplied.
- If establishing control and using Vector as the final adjustment software, all input, output, and point tolerance ASCII files must be supplied.
- If localizing, a transformation report must be supplied.

#### 7.3. PRECISION AND ACCURACY REQUIREMENTS

- Accuracy 0.025 ft. horizontal, 0.04 ft. vertical to base
- Occupation 2 observations , 4 hour differential
- PDOP less than or equal to 5
- Satellites 5 or more

# 8. RT SURVEYS

#### 8.1. CHECK-IN POINTS

- Every project using RT methods will have a minimum of two check-in points established. The points will be within the limits of the RT survey and can be one and the same as the PNC points. (See establishment of check in points, Section 10).
- Every project using RT methods will check into check in points before beginning each day's data collection, at a minimum of every 2 hours thereafter, and at the conclusion of the day's data collection.

#### 8.2. OBSERVATIONS

- Typical RT observations are single epoch. This will be the accepted procedure for both data collection and control point check-ins.
- Low precision observations require a single observation.
- Higher precision observations require at least two observations taken at a minimum of 30 minutes apart.

#### 8.3. LOCALIZATION

- Localization is defined as the coordinate transformation from the GNSS reference system to the project specified system as defined by Department approved control.
- Transformation should be constrained by a minimum of 3 horizontal and 3 vertical stations (a station can represent both a horizontal and vertical constraint) in the project vicinity with published coordinate values in the project specified system.

#### 8.4. DELIVERABLES

Raw data file converted to RINEX, open source, or other Department approved format and delivered in electronic form for each session.

#### 8.5. PRECISION AND ACCURACY REQUIREMENTS

- Accuracy 0.07 ft. horizontal, 0.10 ft. vertical to base
- Occupation 2 check-in locations, 2 hour differential (See 8.1)
- GDOP less than or equal to 5
- Satellites 5 or more

#### 9. RTN SURVEYS

#### 9.1. CHECK-IN POINTS

- Every project using RTN methods will have a minimum of two check-in points established. The points will be within the limits of the RTN survey and can be one and the same as the PNC points. (See establishment of check-in points, Section 10).
- Every project using RTN methods will check into check-in points before beginning each day's data collection, at a minimum of every 2 hours thereafter and after completion of the day's data collection.

#### 9.2. OBSERVATIONS

- Typical RTN observations are single epoch. This will be the accepted procedure for both data collection and control point check-ins.
- Low precision observations require a single observation.
- Higher precision observations require at least two observations taken at a minimum of 30 minutes apart.

#### 9.3. LOCALIZATION

- Localization is defined as the coordinate transformation from the GNSS reference system to the project specified system as defined by Department approved control.
- Transformation should be constrained by a minimum of 3 horizontal and 3 vertical stations (a station can represent both a horizontal and vertical constraint) in the project vicinity with published coordinate values in the project specified system.

#### 9.4. NETWORK CORRECTIONS

Every project using RTN methods will use the FKP, VRS, iMAC, or MAC correctors broadcast by the FPRN for collecting data.

#### 9.5. DELIVERABLES

Raw data file converted to RINEX format and delivered in electronic form for each session.

#### 9.5.1. SURVEYOR'S REPORT

- If localizing, a transformation report must be supplied.
- If using RTN methods, the surveyor's report must state which network corrector was used during the data collection.

#### 9.6. PRECISION AND ACCURACY REQUIREMENTS

- Accuracy 0.07 ft. horizontal, 0.10 ft. vertical to base
- Occupation 2 check-in locations, 2 hour differential (See 9.1)
- GDOP less than or equal to 5
- Satellites 5 or more

# 10. ESTABLISHMENT OF CHECK-IN POINTS

#### 10.1. REQUIREMENTS

Check-in points will be established with the following requirements:

#### 10.1.1. ACCURACY

- The minimum accuracy requirements at the 95% confidence level are:
  - 0.05 ft. horizontal
  - 0.08 ft. vertical

#### 10.1.2. REDUNDENCY

1 check-in point per mile of corridor length with a minimum of 2.

#### 10.1.3. RMS

The RMS value of the observations should be less than 0.05 ft.

#### 10.1.4. INTERVAL

A minimum of 30 minute RS observations with 30 second epochs should be observed during establishment of these points.

#### 10.1.5. SATELLITES

At least 5 satellites should be visible and above the 15 degree elevation mask.

# APPENDIX C ACCURACY REQUIREMENTS