FDM 9-1-1 General

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1.1 Originator

The Chief of the Surveying & Mapping Section is the originator of this chapter. All questions and comments concerning this chapter should be submitted to the Chief Surveying & Mapping Engineer at 608-246-7941, or email surveying issues to geodetic@dot.wi.gov or mapping issues to dotaerialmapping@dot.wi.gov.

1.2 General

As a part of the facilities development process, the department conducts surveys to determine the location, geometrics, quantities, cost, and environmental effects of a transportation improvement project. Surveys are needed for planning, design, real estate acquisition, and construction of a project. The surveyor makes field measurements and captures the relative field relationships between cultural features, natural features, and property boundaries. Some of these relationships may be determined more expediently with aerial imagery or scanning; however, field surveys are needed to set ground control for the aerial imagery or scanning and to locate field features such as underground utilities that are not identifiable by imaging or scanning.

This chapter describes the standards and procedures that are necessary to provide high-quality, comprehensive survey data for project development. A planimetric map, digital terrain model, geodetic survey control, and engineering (project) control are typical surveying and mapping products.

FDM 9-1-5 Description of Surveys

December 21, 2010

Surveys conducted by the department may be classified as either control surveys or engineering surveys depending on the scope of an improvement project. This determination is made based on the criteria contained in FDM 9-35-5 and FDM 9-40-5. Horizontal control surveys conducted by the department are oriented to the most current and appropriate horizontal datum as described in FDM 9-20-15. Vertical control surveys conducted by the department are orientated to the most current and appropriate vertical datum as described in FDM 9-20-20.

5.1 Engineering Surveys

Engineering surveys include surveys to gather detail engineering data, such as cross sections, topography, and drainage information. These surveys are generally not control surveys, as their purpose is not establishment of horizontal or vertical position data from which other surveys may originate. Generalized adjustment procedures are not employed for engineering surveys; however, error distribution is applied. An example of this is the adjustment of height of instrument (HI) elevations for the misclosure at the ending bench mark of a cross-section survey.

Although engineering surveys are not executed as control surveys, specifications for the measurements are employed. The specifications for the measurements are not as rigorous as they are for control surveys, but they are designed to ensure the adequacy of the measurements.

Specifications for engineering surveys are given in the appropriate sections of this chapter.

Engineering Surveys may also be generated from scanning methods.

5.2 Control Surveys

Control surveys are surveys that establish horizontal and/or vertical positions for points from which other surveys may originate. They are surveys conducted according to specifications designed to attain a desired standard of accuracy. They are adjusted by prescribed methods to orient the survey to a recognized datum.

The specifications are designed to minimize the effect of random and systematic errors, and to obtain a predetermined degree of accuracy. The specifications include requirements for geometric configuration; monumentation and instrumental quality; and method, number, and tolerance for the measurements.

The standard of accuracy attained is defined as the relative accuracy or uncertainty between adjacent points positioned to similar specifications. The relative accuracy or uncertainty is determined through a review of the specifications employed, the geometric configuration of the survey, and an evaluation of adjustments to the

measured data. A review should also take into consideration the effect of constraints and established control used in the adjustment.

A survey conducted under specifications of a lower order of accuracy than the stations to which it is adjusted cannot be classified to an order of accuracy higher than the specifications employed, even though the position closures obtained may indicate a higher order of accuracy. Closure is not the sole criterion for classifying survey accuracy. All specifications must be met. A survey employing specifications of a higher order of accuracy than the stations to which it is adjusted cannot be classified to an order of accuracy higher than that of the existing control stations.

5.3 Primary Control Surveys

The primary control survey is normally the initial survey for an improvement project. Its purpose is to increase the density of permanent, high-order, horizontal and vertical control points from which subsequent surveys may originate. The primary control survey may include points that are needed for further project definition such as U.S. Public Land Survey System corners, points of intersection (PIs), and points required for photogrammetric applications. However, these points should only be included if they do not affect the integrity of the primary control survey. Therefore, inclusion of points needed for further project definition at the cost of weakening the primary control should be avoided. Height Modernization Program stations may be sufficiently dense to constitute primary control.

5.4 Secondary Control Surveys

On projects where a primary control survey is necessary to increase the density of high-order control, the secondary control survey is usually the next survey performed. When there is adequate existing primary control, the secondary control survey may be the first survey performed.

This survey establishes conveniently located, intervisible, yet well-spaced points throughout the length of the project from which alignment, right-of-way, and photogrammetric surveys may originate. It may include points common to these other surveys provided station spacing requirements are met.

Secondary control surveys are often established in stages. Because highway projects are lineal, and because secondary control is usually established early in the development process, an initial secondary control survey is used to establish control linearly throughout the project and includes connections to primary control. As a project develops and U.S. Public Land Survey System corners are recovered or reestablished, supplemental secondary control surveys are run to establish coordinate control on the land corners.

5.5 Alignment Surveys

An alignment survey defines a centerline or reference line of a project. Alignment surveys may be coincident with the project base control survey when an alignment can be surveyed early in project development and adequate station spacing can be obtained. When the alignment surveys are not coincident with project base control, the alignments are either laid out from, or tied to, the base control survey to establish coordinates on the alignment surveys.

An alignment survey establishes a line to which engineering-data-gathering surveys to obtain topography, cross sections, and other needed engineering information are referenced. Normally, the horizontal alignment survey is executed as a control survey; however, based on the criteria contained in FDM 9-35-1, there are cases when a control survey is not required. In these cases, the horizontal alignment survey is not preceded by project base control or primary control surveys, and it is then the first survey executed for a project.

Alignment surveys, including the main line and crossroads, shall be stationed every 100 feet from west to east or from south to north based on the overall direction of the route involved.

5.6 Photogrammetric Surveys

Photogrammetric surveys use aerial imagery and sometimes LiDAR scanning to define surface features and a digital terrain model (DTM). Photogrammetric surveys may need to be supplemented with field surveys in areas obstructed from view of the aerial camera (under a structure or tree canopy) or where changes may have occurred since the date of the flight.

Field surveys are required to establish vertical and horizontal control for photogrammetric applications and may occur at several points during the project development process. Except for certain operations involving photo-identifiable panels or image points, surveying procedures do not significantly differ from Secondary Control surveys.

Detailed survey requirements for aerial projects can be found in FDM 9-45.

5.7 Right-of-Way Surveys

A right-of-way survey marks the right-of-way boundaries and establishes the right-of-way reference line, if necessary. The right-of-way reference line will normally be the same line as the project reference line. Right-of-way surveys may also include surveys to gather information on property lines, lines of occupation, and land improvements.

FDM 9-1-10 Automation Links to Surveys

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New technologies and methods are changing the way information is collected, stored, processed, used, and passed between parties. These changes are constantly evolving. For up-to-date information contact the originator of this chapter.

FDM 9-1-15 Need for Accuracy

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The quality of the information in a survey database is important to its users. It should never be necessary to think of a centerline station distance as being plus or minus 1 foot. It is not acceptable to establish and to measure a project centerline using a cloth tape, or to run a level circuit using a wooden folding rule and a hand level. While these are extreme examples, they demonstrate that standards and procedures are necessary and that the economic use of standards and procedures requires the methods selected for use be designed to attain the desired results. Therefore, standards and procedures should be thought of as a means of applying quality control to the information in a survey database.

For an explanation of precision and accuracy, consult a surveying textbook (e.g., *Elementary Surveying: An Introduction to Geomatics,* by Ghilani) or similar resource.