Rules of
Department of Commerce and Insurance
Division 2030—Missouri Board for Architects, Professional Engineers, Professional Land Surveyors, and Professional Landscape Architects
Chapter 18—First and Second Order Horizontal and Vertical Control

Title 20—DEPARTMENT OF COMMERCE AND INSURANCE
Division 2030—Missouri Board for Architects, Professional Engineers, Professional Land Surveyors, and Professional Landscape Architects
Chapter 18—First and Second Order Horizontal and Vertical Control

20 CSR 2030-18.010 Definitions

PURPOSE: This rule defines technical terms used in Chapter 18.

(1) Positional accuracy of a station is the uncertainty in the position of the station relative to the stations that are held fixed (i.e., National Geodetic Survey (NGS) or other higher order stations) in the process of the adjustment. Positional accuracy of a station is computed from the constrained, correctly weighted, least squares adjustment at the ninety-five percent (95%) confidence level.

(2) Relative accuracy is the uncertainty in the position of one (1) station relative to another station. It is computed for all directly connected stations from the minimally constrained, and the constrained correctly weighted, least squares adjustment at the ninety-five percent (95%) confidence level.

(3) Rural area—For purposes of this chapter, a rural area is any second, third, or fourth class county according to 48.020, RSMo.

(4) Urban area—For purposes of this chapter, an urban area is any first class county according to 48.020, RSMo.

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20 CSR 2030-18.020 Horizontal Control Classification

PURPOSE: This rule describes the classes of horizontal control.

(1) First Order Horizontal Control Classification. The purpose of this class of survey is to establish primary horizontal control for the Missouri Geographic Reference System or the National Spatial Reference System.

(2) Second Order Horizontal Control Classification. The purpose of this class of survey is to establish secondary and supplemental horizontal control stations of the Missouri Geographic Reference System or the National Spatial Reference System.

(3) Both first and second order stations are dependent stations constrained to the existing first and second order stations of the Missouri Geographic Reference System and/or the National Spatial Reference System. These stations are intended to be used to meet the needs of mapping, geographic information systems, land information systems, property boundary surveys, and design surveys.

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20 CSR 2030-18.030 Accuracy of Horizontal Control

PURPOSE: This rule prescribes the acceptable accuracy of first and second order control.

(1) The accuracy of a horizontal control station is classified according to constrained and unconstrained, relative accuracy of the distance between stations, and the positional accuracy of the station relative to the stations held fixed in the adjustment. If the requirements for all three (3) criteria are not satisfied, the station shall fail to qualify for the classification.

(2) First Order Horizontal Control.

(A) The relative accuracy of the distance between directly connected adjacent stations shall be equal to or less than twelve millimeters (12 mm) for distances equal or less than one kilometer (1 km) and ten parts per million (10 ppm) for distances greater than one kilometer (1 km).

(B) The positional accuracy of a station shall be thirty millimeters (30 mm) in urban areas and sixty millimeters (60 mm) in rural areas.

(3) Second Order Horizontal Control.

(A) The relative accuracy of the distance between directly connected adjacent stations shall be equal to or less than twenty-five millimeters (25 mm) for distances equal to or less than one kilometer (1 km) and twenty parts per million (20 ppm) for distances greater than one kilometer (1 km).

(B) The positional accuracy of a station shall be sixty millimeters (60 mm) in urban areas and one hundred (100) mm in rural areas.

(4) To fully qualify as a first or second order control station, the station must be accepted and published by the Missouri Department of Agriculture or the National Geodetic Survey or its successor organization.

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20 CSR 2030-18.040 Acceptance and Publication by Missouri Department of Agriculture

PURPOSE: This rule designates the procedures for determining which control will be a part of the Missouri Geographic Reference System.

(1) The following information will be submitted for each control survey that is to be evaluated for inclusion into the Missouri Geographic Reference System (MO GRS) as a first or second order station.

(A) A sketch will be submitted showing all stations occupied during the control survey. In addition to occupied stations, the sketch should show other existing horizontal or vertical stations located within or near the project area.

(B) A legend on the sketch should show the following information:

Project Name
General Locality
Name of organization performing observations
Date of project start and completion

(C) A north arrow and graphic scale should appear on the sketch. All station symbols should be labeled with the station name. When stations are spaced too closely together to be clearly depicted on the network sketch, an inset shall be used.

(2) A report shall be submitted for each project and shall be signed and sealed by the professional land surveyor or professional engineer in responsible charge. The report shall be the main source of information for judging whether or not the stations should be accepted as MO GRS stations. It shall be the responsibility of the professional land surveyor or professional engineer to supply sufficient information in the report to facilitate inclusion of the stations in the MO GRS.

(3) The report shall contain a clear description of the survey procedures and equipment used in the field. This includes, but is not limited to, the information entered into the field log and auxiliary information such as logistics, preanalysis satellite selection results (if Global Positioning System (GPS) survey), personnel involved, and difficulties encountered.

(4) In the report there shall be a clear description of the procedures used in the office. This includes, but is not limited to, computer software and hardware used to process observations, options used (if any), data editing performed, source of orbital data (if GPS survey), parameters adjusted and held fixed, results of self-validation, and any difficulties encountered.

(5) The following shall be included for GPS surveys. The version number and date of the GPS software used must be reported. For GPS surveys, the professional land surveyor or professional engineer must also specifically report the baselines rejected for the project. All parameters used for any coordinate transformations shall be presented and any scaling of the covariance matrix by the professional land surveyor or professional engineer must be described in detail. If the covariance matrix has been scaled, the scale factor used must also be presented. These results must be reported for all single baseline and network solutions. Statistical testing of the survey results from the network solution, including analysis of variance factors, semi-major axis of two- (2-) dimensional (horizontal) or three- (3-) dimensional (horizontal and vertical) ninety-five percent (95%) relative confidence regions between all directly connected pairs of stations, residuals and residual outliers shall be provided. In addition, the results of any self-validation checks must be reported, including, but not limited to, comparisons of any repeated single baseline solutions.

(6) For traverse surveys, all field data used to determine directions, distances, azimuths, and elevations, as well as the adjustment calculations, shall be submitted along with the name of the software used in the adjustment. The data submitted shall show the final results of the adjustment and the error analysis.

(7) Only those stations meeting the requirements of 2 CSR 90-62.030, 2 CSR 90-62.040, 2 CSR 90-62.050, and 2 CSR 90-62.060 will be accepted for publication in the MO GRS.

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20 CSR 2030-18.050 GPS Survey Guidelines

PURPOSE: This rule prescribes the minimum procedures for first or second order Global Positioning System surveys.

(1) Direct connections must be made to any adjacent observable National Spatial Reference System (NSRS) and/or Missouri Geographic Reference System (MO GRS) station located five kilometers (5 km) or less from any new station.

(2) At least three (3) existing higher or equal order control points must be included in any proposed Global Positioning System (GPS) survey. Whenever possible, these should be three (3) three- (3-) dimensional control stations. Otherwise, two (2) sets of three (3) stations (three (3) two- (2-) dimensional horizontal stations and three (3) vertical control stations) must be used. These control stations should be chosen to be roughly equidistant on the periphery of the proposed project so that they enclose as much of the project as possible.

(3) Each new station to be established by the proposed GPS survey must be occupied at least two (2) separate times to enable proper checking of blunders (for example, incorrect point, setup errors, incorrect antenna heights). A separate occupation is one in which the antenna and its supporting device (tripod) have been taken down and set up again and the receiver restarted.

(4) Each station must be connected by simultaneous occupations (baselines) to at least three (3) other stations in the network after outlier baselines have been rejected from the adjustment. Because it is generally easier to resolve the integer phase ambiguities over shorter base line, adjacent stations should be connected wherever possible.

(5) At least two (2) receivers must be used for relative positioning, although three (3) or more may be used for more efficient operation and increased station reoccupation and base line repeatability.

(6) A preanalysis should be performed to determine the minimum occupation time required to achieve the required standard of accuracy. In addition, the most appropriate satellites to observe at each site should also be selected for receivers unable to track all of the "visible" satellites. The preanalysis should be specific for carrier phase relative positioning.

(7) In order to meet second order accuracies, the carrier beat phase must be observed together with a time tag for each observation. Pseudo-range observations are not precise enough for control surveys and cannot be used.

(8) A detailed field log must be kept during observation taken at each station. At the very least, the following information must be recorded:

(A) Universal Time Coordinated (UTC) date of observations;

(B) Station identification (name and number);

(C) Session identification;

(D) Serial numbers of receiver, antenna, and data logger;

(E) Receiver operator;

(F) Antenna height and offset from monument, if any, to one millimeter (1 mm). Note should be made as to whether the height is measured as a slant height or vertical height;

(G) Diagram illustrating stamping on the monument;

(H) Other stations observed during session;

(I) Starting and ending time (UTC) of observations;

(J) Satellites observed (including time of changes); and

(K) Completed field log data forms for each station occupation will be submitted either using those provided by the Missouri Department of Agriculture (MDA) or some other type containing all necessary information included on the MDA forms.

(9) The raw data files for all station occupations must be submitted. Each file will consist of one (1) set of raw observations for each station occupation session. For example, four (4) receivers operating during each of five (5) sessions will produce twenty (20) raw data files.

(10) The unadjusted baseline vector solution files for all observed baselines, non-trivial and trivial, will be submitted.

(11) If station description information is not provided by MDA, it must be submitted for each station occupied. Station descriptions must include station name, county, township, range, section, United States Geological Survey (USGS) seven and one-half (7.5) minute quadrangle name, date monumented, date of observations, complete descriptions of the station, azimuth and all reference monuments, a current "to reach" description, and any special information such as property owner name, address, and phone number. A sketch depicting the station and reference marks with dimensions and directions shown should accompany all narrative data. Examples of complete station description information may be obtained from MDA.

(12) If the GPS survey project includes any surveys using conventional or terrestrial horizontal surveying techniques, copies of all field notes and associated data must be submitted. This would include eccentric point establishment and reduction. Polaris, solar, or direct observational data to establish azimuth marks shall also be submitted.

(13) When the GPS survey project includes surveys performed using conventional differential leveling techniques, copies of all field notes and associated data must be submitted. An example of this would be a vertical tie from a non-occupied bench mark to a GPS station.

(14) A tabulation of the results of the repeat base line comparisons will be included in the project report.

(15) A minimally constrained (free) least squares, three dimensional (3-d) adjustment will be submitted in the form of the input and output files.

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20 CSR 2030-18.060 Traverse Survey Guidelines

PURPOSE: This rule prescribes the minimum procedures for first or second order traverse surveys.

(1) First Order Traverse Procedure.

(A) The location of first order traverse lines and monumented stations shall be determined by a thorough field reconnaissance. The traverse point spacing shall not be less than six hundred meters (600m).

(B) All first order traverse lines shall start from, and close upon, first order stations or higher order stations of the Missouri Geographic Reference System (MO GRS) or National Spatial Reference System (NSRS) in accordance with these procedures.

(C) Properly maintained theodolites with a least count of one second (1") or a DIN 18723 specification of one and one-half seconds (1.5") or smaller shall be used to observe directions and azimuths. At least four (4) positions or repetitions of the angles shall be observed. The theodolite and targets should be centered to within two millimeters (2 mm) over the survey station or traverse point.

(D) Electronic distance measuring (EDM) instruments shall be used to measure all distances. EDM instruments shall be tested on a Missouri Department of Agriculture (MDA) base line at the start of and on the completion of any first order traverse. Copies of the EDM base line comparisons shall be included in the survey report submitted to the department. Barometric pressure to the nearest five millimeters (5 mm) of mercury and temperature to the nearest one degree Celsius (1°C) shall be recorded for each measurement.

(E) Each traverse shall be tied to a minimum of two (2) bench marks. Trigonometric or spirit leveling will be observed along all traverse lines. All Instrument Heights (HIs), Reflector Heights (HOs) and zenith angles shall be recorded and submitted.

(F) The traverse shall be controlled by an astronomic azimuth at each end of the traverse line and at not more than every six (6) segments along the line. Astronomic azimuths shall have a standard deviation of one and one-half seconds (1.5") or less.

(G) All field data shall be submitted to Missouri Department of Agriculture (MDA) in a format acceptable to the department. This shall include directions, distances, azimuth, and elevations.

(2) Second Order Traverse Procedure.

(A) The location of second order traverse lines and monumented stations shall be determined by a thorough field reconnaissance. The traverse point spacing shall not be less than three hundred meters (300m).

(B) All second order traverse lines shall start from, and close upon, second order or higher order stations of the MO GRS or NSRS in accordance with these procedures.

(C) Properly maintained theodolites with a least count of one second (1") or DIN 18723 specification of one and one-half seconds (1.5") or smaller shall be used to observe directions and azimuths. At least four (4) positions or repetitions of the angles shall be observed. The theodolite and targets should be centered to within two millimeters (2 mm) over the survey station or traverse point.

(D) Electronic distance measuring (EDM) instruments shall be used to measure all distances. EDM instruments shall be tested on an MDA baseline at the start of and on the completion of any second order traverse. Copies of the EDM baseline comparisons shall be included in the survey report submitted to the department. Barometric pressure to the nearest five millimeters (5 mm) of mercury and temperature to the nearest one degree Celsius (1°C) shall be recorded for each measurement.

(E) Each traverse shall be tied to a minimum of two (2) bench marks. Trigonometric or spirit leveling will be observed along all traverse lines. All HIs, HOs, and zenith angles shall be recorded and submitted.

(F) The traverse shall be controlled by an astronomic azimuth at each end of the traverse line and at not more than every eight (8) segments along the line. Astronomic azimuth shall have a standard deviation of two seconds (2") or less.

(G) All field data shall be submitted to the MDA in a format acceptable to the department. This shall include directions, distances, azimuth, and elevations.

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20 CSR 2030-18.070 Waiver of 1 Km Limitation
(Rescinded June 30, 2017)

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