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One component of the Division's GOM goal on High-Tech Utilization was a review to determine the optimum techniques for collecting terrain data for design. Principally, we wanted to know when it is best to use ground survey and when the method of choice should be photogrammetry. That review has resulted in the attached rewritten section 5.04 of the Highway Design Manual.

This section now entitled Terrain Data Requirements for Design has been written to provide an updated policy on the type of terrain data required and the most efficient method of collecting the data for a given type of project. The project design engineer is responsible for following these guidelines in selecting the appropriate terrain data and the regional survey supervisor is responsible for selecting the method of data collection.

This document is based on current design requirements and equipment capabilities. As these requirements change or other circumstances warrant, this section will be updated. This rewritten section will be included in the next general update of the Highway Design Manual.

5.04 TERRAIN DATA REQUIREMENTS FOR DESIGN

5.04.01 General

When required, terrain data for design may consist of planimetric or topographic mapping, cross sections or digital terrain models (DTM). The terrain data product is dependent on the type of project and the area where it is located. The data can be collected by either photogrammetry or field survey; or a combination of the two.

This section is written to provide a guideline as to the type of terrain data to request and the most cost effective method of collecting the data for a given type of project. In preparing this section the following factors were considered; the size and scope of typical projects, the time generally required to move from data collection to start of design, estimated costs of data collection and the level of accuracy needed for elevation data. Following these guidelines the project design engineer is responsible for selecting the appropriate terrain data and the regional survey supervisor is responsible for selecting the method of data collection. In making these selections other factors specific to the project and site should also be considered.

5.04.02 Method of Data Collection

Photogrammetry and field survey can provide terrain data in the form of planimetric or topographic mapping, cross sections and DTM's. In general, field survey can achieve greater accuracy than photogrammetry. However photogrammetry is sufficiently accurate for most applications and is generally less expensive for all but very small projects. Thus, because of the cost effectiveness of photogrammetry, it should be used whenever appropriate.

For mapping, photogrammetry can provide an accurate, comprehensive, digital product at less cost than field survey. However, if a project is short, has dense evergreen or other foliage, requires only mapping of limited features or has not been scheduled in advance, field survey may be the logical choice. Also, field work will be required for most projects to compile some utility, culvert, tree, building and sign data unavailable through aerial photography.

Photogrammetric cross sections and DTM's are also very economical when compared to field surveyed data. However, two factors must be considered. First, photogrammetric cross sections and DTM points have an elevation standard deviation of $\pm$0.2 feet. If higher vertical accuracy than $\pm$0.2 feet is required, vertical data must be field surveyed. Second, dense foliage or other site conditions may obstruct the view of the

ground from the air. If the ground is not visible from the air, vertical data must be field surveyed. If the higher vertical accuracy requirements or obstructed views occur only in limited areas, photogrammetric data can be supplemented with field surveyed elevations. See the attached chart (Figure 1) and the Project Type Section for specific guidelines as to when photogrammetry or survey should be used.

5.04.03 Terrain Data Products

Mapping for design projects is generally provided at 1"=40' scale or 1"=50' scale with 2', 1' or no contours. 1"=20' scale mapping can be provided for urban areas or bridge sites.

Cross sections are provided at 50' or 100' intervals (with plus stations) along a defined baseline, geometric centerline or the visual centerline closely represented by tangent segments. Design cross sections which also are to be used by Construction for volume payment will be generated along a (preliminary) geometric centerline, or visual centerline, - not a baseline.

DTM's are an optional substitute for contours and cross sections. They allow considerably more flexibility for design and potential follow-up use by construction. Using the DTM approach cross sections for construction volume payment purposes can be easily created along the final design centerline. Cross sections extrapolated from DTM's will be slightly less accurate than directly measured cross sections.

DTM's should be requested only if the project will be designed using the CADD system's automated design software or cross sections along multiple alignments are required. If the design is to be accomplished manually or using CADRE and only one set of cross sections is required then standard cross sections should be requested rather than a DTM.

All photogrammetric mapping is compiled digitally in 2D files for the Department's CADD system. Photogrammetric cross sections are also in digital form and can be used with the Department's CADD system or the Burroughs system. Photogrammetric DTM's are provided in a format suitable for use with the Department's CADD system and automated design software. More information on photogrammetry products and how to request them is available in the Catalog of Photogrammetric Services.

Field surveyed projects can be submitted using data collectors with the data formatted to be compatible to the Department's computer design systems. Manually recorded notes can also be used to supplement electronically recorded survey data and/or to complete needed cross sections, mapping, DTMs, or other survey tasks. Electronic recording survey methods should be used whenever possible to efficiently complete the mapping process. However, practices vary from region to region and the regional survey supervisor should be contacted for information on the products available.

Categorized below are the amount and type of terrain data that will generally be required and the method of data collection for each project type. Some projects may have varying requirements, however, which may necessitate a different combination of products in some areas. In addition to the description below, also refer to the attached chart. (Figure 1)

I. MAJOR PROJECTS (New Construction)

A. Project Type

These projects consist of work such as construction of major streets, expressways, freeways, interchanges, climbing lanes, frontage roads, exit/entrance ramps, or construction of additional travel lanes along an existing roadway. Also included would be those projects that involve total highway reconstruction work, or realignment and/or relocation work.

B. Terrain Data Required

Large scale mapping with vertical data portrayed by contours and cross sections or DTM's will generally be required for projects of this type. The mapping coverage that is requested for these projects should be for a band width that is sufficient to prepare the plan of the project in accordance with the approximate alignment and layout.

Map scale: 1"=40' or 1"=50'

Contour Interval: 2' standard, 1' contours if required

Cross Sections: Stationing at 50' or 100' intervals (with plus stations)

DTM: Digital terrain model data can be collected instead of direct contour and cross section compilation. Contours and cross sections can then be computer generated from the DTM. Either directly compiled contours and cross sections or DTM data can be requested, but not both.

C. Method of Collection

For major projects, due to their size and the amount of data to be collected, photogrammetry should be used for mapping, cross sections, and DTM's. Field surveyed data must be used to supplement the photogrammetry data if high accuracy is needed in critical areas.

II. BRIDGE SITE PROJECTS

A. Project Type

These projects consist of new bridge construction or bridge replacement work. Bridge Rehabilitation projects will generally not require any terrain data.

B. Terrain Data Required

Large scale mapping with vertical data portrayed by contours and cross sections or DTM's will generally be required for projects of this type. 1"=20' mapping is generally required for the bridge sites. It can be prepared for use at 1"=20' or generated by the designer by enlarging 1"=40' or 1"=50' mapping on NYSDOT's computer graphics system. The mapping coverage that is requested for these projects should be limited in area, but include areas of necessary approach work and upstream and downstream areas.

Map Scale: 1"=20' (or 1"=40' or 1"=50' which can be converted to 1"=20')

Contour Interval: 2' standard, 1' contours if required

Cross Sections: Stationing at 50' (with plus stations) Cross sections can also be taken perpendicular to the stream flow.

DTM: Digital terrain model data can be collected instead of direct contour and cross section compilation. Contours and cross sections can then be computer generated from the DTM. Either directly compiled contours and cross sections or DTM data can be requested, but not both.

C. Method of Collection

For bridge site projects with mapping requirements of over 15 acres, photogrammetry should be used. For those sites requiring mapping for under 15 acres photogrammetry and/or survey may be used depending upon the level of mapping detail required. Photogrammetric methods can also be used for bridge sites which have terrain characteristics that make field survey difficult. Field survey will be needed to obtain supplemental data at bridge sites, such as underwater and under-structure data which cannot be obtained from the aerial photography.

For cross sections, field survey should be used due to the accuracy generally required at bridge sites and the foliage conditions usually present. Photogrammetry can be used if the cross sections are extensive or in difficult terrain. In such cases photogrammetric cross sections should be compiled and supplemented by field surveyed cross sections where vertical accuracy requirements are critical.

If DTM's are to be produced, they should be collected photogrammetrically for sites requiring data for over 15 acres. However, the DTM must be supplemented by field surveyed data where vertical accuracy is critical. Photogrammetry or survey may be used for those sites requiring data for under 15 acres depending upon the terrain, foliage conditions, and accuracy required.

III. MAJOR R & P PROJECTS

A. Project Type

These projects are characterized by considerable or moderate traffic service improvements. Typically some of the work involved in upgrading the roadway would include pavement widening, construction of superelevations, conversion of shoulder areas to travel lanes, replacement of inadequate foundation material for short sections of the roadway, shoulder widening and/or stabilization, curb rehabilitation and replacement, sidewalk and driveway improvements, culvert and roadside drainage improvements, upgrading of guiderails, signing, pavement marking, and other work in addition to resurfacing.

B. Terrain Data Required

Large scale mapping with vertical data will generally be required for projects of this type. Only one vertical data set - directly compiled contours, or directly compiled cross sections, or DTM's should be requested. However, if cross sections are selected, 5' contours can also be requested if required.

The projects in this category will usually involve significant ROW acquisition. The typical mapping band for projects which involve ROW work is 400 feet. For projects which do not involve ROW changes, a mapping band as narrow as 200' may be adequate. Additional coverage may also be provided

along intersecting side roads and streams. Contours with 2' or 1' intervals and cross sections can be provided in sensitive drainage areas. Cross sections and 5' contours can be provided for the entire project if required.

Map Scale: 1"=40' or 1"=50'

Contour Interval: 2' standard, 1' contours if required

Cross Sections: Stationing at 50' for urban and developed areas.

Stationing at 100' for rural areas. If cross sections are to be used by construction then 50' stationing should be used.

DTM: Digital terrain model data can be collected instead of direct contours and cross section compilation. Contours and cross sections can then be computer generated from the DTM.

Note that only one set of vertical data should be requested; directly compiled contours, or cross sections or DTM data.

C. Method of Collection

For major R & P projects over 1/4 mile long photogrammetry should be used for mapping, cross sections and DTM's. For those projects under 1/4 mile long photogrammetry or survey may be used depending on how comprehensive the terrain data requirements are. Field surveyed data must be used to supplement the photogrammetry data if high accuracy is needed in critical areas.

IV. MINOR R & P PROJECTS

A. Project Type

These projects involve primarily resurfacing. Other traffic service improvements will generally be accomplished for projects in this category, but the work to be done is not as comprehensive or as complex as for those projects in the above categories. In addition to resurfacing work, projects in this category may involve work that includes widening of narrow lanes, shoulder widening

and stabilization, some drainage improvement, the installation or replacement of signs and/or guiderails and other minor improvements. Some simple resurfacing and similar projects will not require any mapping since plans will not be part of the contract.

B. Terrain Data Required

Large scale planimetric mapping will generally be required for these minor R & P projects. Contours and DTM's will not be required. Full project cross sections will generally not be required. However, some cross sections for limited areas may be needed. For simple resurfacing projects mapping will not be required. Since projects in this category generally do not involve additional ROW acquisition, the mapping band requested should typically be quite narrow. The band should generally be less than 400' with 200 feet being adequate for most projects. Some features such as vegetation may be required in only selected areas. Another option is skeletal coverage consisting of very limited data such as pavement and shoulder edges.

Map Scale: 1"=40' or 1"=50'

Contour Interval: Not required

Cross Sections: Generally not required

DTM: Not required

C. Method of Collection

For minor R & P projects over 1/2 mile long, if full band mapping is needed it should be acquired by photogrammetric methods. For those projects under 1/2 mile long photogrammetry or survey may be used, depending upon the complexity of the mapping. If only skeletal coverage consisting of very limited data such as pavement and shoulder edges is needed then photogrammetric methods should be used only for projects over 2 miles. Field survey should be used for skeletal coverage of projects under 2 miles.

If cross sections are required for limited areas photogrammetry or survey can be used. If only high accuracy pavement elevations are needed then field survey must be used. If more extensive cross section data is required photogrammetry should be used.

V. PLANNING STUDIES

A. Project Type

These projects consist of major projects requiring highway corridor selection, and extensive planning studies involving areawide transportation study.

B. Terrain Data Required

Small scale mapping will be provided for these projects only when existing mapping (1:24,000 topographic quad sheets, existing 1"=200' scale mapping, or 1:9600 planimetric mapping), or new photographic enlargements are not acceptable for the project. Because of the extremely high cost of 1"=200' mapping, special care should be taken to confine the requested mapping to as small an area as possible.

Map Scale: 1"=200'

Contour Interval: 5' standard

Cross Sections: Not required

DTM: Not required

C. Method of Collection

Due to the size and the amount of data to be collected, photogrammetric methods will be used to produce all planning mapping.

FIGURE 1

PRIMARY METHOD OF TERRAIN DATA COLLECTION

This chart is a summary of Design Manual Section 5.04 Terrain Data Requirements for Design. The chart cannot be applied in proper context without reading Section 5.04.

PROJECT TYPE	PLAN MAPPING	TOPO MAPPING	CROSS SECTIONS	DTM
MAJOR PROJECTS (New Construction)	P	P	P (1)	P (1)
BRIDGE SITE PROJECTS				
over 15 acres	P	P	S	P (1)
under 15 acres	P/S (2)	P/S (2)	S	P/S (2)
MAJOR R&P PROJECTS				
over 1/4 mile	P	P	P (1)	P (1)
under 1/4 mile	P/S (2)	P/S (2)	P/S (2)	P/S (2)
MINOR R&P PROJECTS				
Full band coverage (3)				
over 1/2 mile	P	NA	P (1)	NA
under 1/2 mile	P/S (2)	NA	P/S (2)	NA
Skeletal coverage (3)				
over 2 miles	P	NA	P	NA
under 2 miles	S	NA	S	NA
Resurfacing only	NA	NA	S	NA
PLANNING STUDIES	P	P	NA	NA

P Photogrammetry
S Survey

(1) Survey elevations must be used to supplement photogrammetry elevations if high vertical accuracy is needed in critical areas.

(2) Photogrammetry, survey or a combination of both can be selected depending upon the level of mapping detail or amount of cross section or DTM data required.

(3) For Minor R & P Projects, full coverage consists of collecting data for up to a 400' wide band; skeletal coverage consists of very limited data, such as pavement and shoulder edges.