



STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

BEVERLY EAVES PERDUE
GOVERNOR

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SECRETARY

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To: Location & Survey Staff
Private Engineering Firms

From: Charles W. Brown, PE, PLS
State Location & Surveys Engineer

Subject: Proc 2009-2
Standards for High Density Laser Scanning of Pavement

This specification of procedures for high density laser scanning shall be applied to the two primary applications of scanning for the acquisition of data to create DTM/DEM files for pavement. This will address the acquisition and delivery of data for:

- 1) Pavement DTMs for design surveys (i.e. New Location, Widening, Bridges, etc., where pavement is not the only concern of the project)
- 2) Pavement DEMs for analysis related to resurfacing, irregularities, quality assurance

This memo will address each application separately. These specs are to be used as a guide for data acquisition and product delivery on NCDOT projects. These specs are in no way intended to override the equipment specs as defined by the manufacturer, nor are they to be used in lieu of good surveying practice and procedures. Any individual constraints used by the supplier of the data which exceeds these specs in quality or accuracy assurance will be allowed.

1) Pavement DTMs for Design Surveys (See Figure 1)

Pavement DTMs for design surveys are produced in order for the designer to have adequate data for roadway design purposes. Each rut, dip, or irregularity is not critical. The most critical characteristics of the pavement is typical width, identification of travel lanes and shoulder areas, and a good definition of each individual lane surface. Accuracy should be in the 0.05' range.

Target Control Points

Each individual scan set-up will have a minimum of 4 control targets. Target control points will be rebar or 8" bridge spike (or larger) in soil, PK nail in pavement or other semi-permanent survey mark. Target locations will be placed directly across the project from each other and along both sides of the project, with no adjacent targets greater than 500' apart. The horizontal component (x and y) of each target control point will be established using VRS or conventional surveying methods and tied to localized project control. The vertical component of target locations will be established using conventional leveling methods (trig levels or differential levels using a conventional or digital level) and tied to project control. Target locations will be established to within a tolerance of +/- 0.03 feet. Targets are to be vendor specified 2D or 3D, on fixed tripods.

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Proc 2009-2 Scan Specs.doc

Scan/DTM Validation Points

Scan/DTM Validation Points will be identified points in the scanned surface, with coordinates and elevation obtained through independent survey procedures (not solely through scanning). These may be paint dots on the edge of pavement or some other semi-permanent point which may be returned to at a later date. The location of these validation points shots will established to within a tolerance of +/- 0.03 feet. Each individual scan will have a minimum of three validation points, one at either end (in the overlap area or near the end of the usable limits), and one in the approximate scan linear center. These points do not have to be in the travel way, but may be on the paved shoulder.

These points will be used to compare to the raw data, evaluating the elevation of the nearest scanned point(s) to the validation point. No measured point should have a difference greater than 0.05' from the nearest scanned point.

These points will also be used in the development of a spreadsheet, identifying the difference in elevation between the coordinated point as surveyed and the elevation of the point as computed from the developed DTM. This difference will be provided to the NCDOT in a report format addressing elevation differences between the DTM and actual scanned point elevations. The RMSE of all data should be 0.05' or less, with no individual elevation difference exceeding 0.10'. All data will be reported to the nearest 0.01'. Figure 2 (attached) is one example of this. Geopak provides a similar report.

Individual Scan Lengths

The allowable length of the area of usable data in each individual scan should comply to manufacturer's standards, but in no case should this distance exceed 600'. Each individual scan includes the four targets identified above, at or near the limits of the scan, plus 15% +/- 5% total overlap with the adjacent scan(s). Targets should be placed in overlap areas where those exist.

As defined above, each scan will include four targets and three independent verification shots, one in the overlap on each end of the scan and one in the middle of the scan. Thus each overlap area will include 2 targets and one independent verification shot.

Breaklines and DTM

Breaklines will be established on, but not limited to, back of curb, face of curb, flow line of curb, edge of pavement, and paint striping. Breaklines may be derived from the scan data or established using conventional survey methods. As crowns may not always be associated with paint striping, a breakline along the crown of the paved surface is not necessary. Edge of pavement may be established using the scan data and reasonable care but with the understanding that the true edge of pavement is often obscured by sediment or grass or other debris encroaching on the pavement. A DTM will be developed from these breaklines and 5' grid of scanned points.

Deliverables

Unless otherwise directed the deliverables for pavement DTMs for design will be:

- The raw data
- An accuracy report (rmse)
- A DTM with breaklines as defined above and points on a 5' grid
- A spreadsheet type report comparing elevations of validation points and DTM points
- A spreadsheet type report comparing elevations of validation points and raw data points

2) Pavement DEMs for analysis related to resurfacing, irregularities, quality assurance (Figures 3 and 4)

Pavement DEMs are developed for surface analysis for specific reasons, most often related to drainage surface irregularities, quantity estimates, or as a quality assurance check on the new pavement surface. As such, these may need to be of a greater accuracy and detail than pavement for roadway design purposes.

Target Control Points

Each individual scan set-up will have a minimum of 4 control targets. Target control points will be rebar or 8" bridge spike (or larger) in soil, PK nail in pavement or other semi-permanent survey mark. Target locations will be placed directly across the project from each other and along both sides of the project, with no adjacent targets greater than 250' apart. The horizontal component (x and y) of each target control point will be established using VRS or conventional surveying methods and tied to localized project control. The vertical component of target locations will be established using conventional leveling methods (trig levels or differential levels using a conventional or digital level) and tied to project control. Target locations will be established to within a tolerance of +/- 0.03 feet.

Targets are to be vendor specified 2D or 3D, on fixed tripods.

Scan/DTM Validation Points

Scan/DTM Validation Points will be identified points in the scanned surface, with coordinates and elevation obtained through independent survey procedures (not solely through scanning). These may be paint dots on the edge of pavement or some other semi-permanent point which may be returned to at a later date. The location of these validation points shots will be established to within a tolerance of +/- 0.03 feet. Each individual scan will have a minimum of three validation points, one at either end (in the overlap area or near the end of the usable limits), and one in the approximate scan linear center. These points do not have to be in the travel way, but may be on the paved shoulder.

These points will be used to compare to the raw data, evaluating the elevation of the nearest scanned point(s) to the validation point. No measured point should have a difference greater than 0.03' from the nearest scanned point.

These points will also be used in the development of a spreadsheet, identifying the difference in elevation between the coordinated point as surveyed and the elevation of the point as computed from the developed DTM. This difference will be provided to the NCDOT in a report format addressing elevation differences between the DTM and actual scanned point elevations. The

RMSE of all data should be 0.03', with no individual elevation difference exceeding 0.05'. All data will be reported to the nearest 0.01'. Figure 2 (attached) is one example of this. Geopak provides a similar report.

Individual Scan Lengths

The allowable length of the area of usable data in each individual scan should comply to manufacturer's standards, but in no case should this distance exceed 300'. Each individual scan include the four targets identified above, at or near the limits of the scan, plus 15% +/- 5% overlap with the adjacent scan(s). Targets should be placed in overlap areas where those exist. In addition, the density of the shots in the scan will be no greater than 0.10 feet apart at a distance of 125 feet from the scanner.

As defined above, each scan will include four targets and three independent verification shots, one in the overlap on each end of the scan and one in the middle of the scan. Thus each overlap area will include 2 targets and one independent verification shot.

DEM

There will be no breaklines required for this product.

Deliverables

The deliverables for pavement DEMs for pavement analysis will be:

- The raw data
- An accuracy report (rmse)
- A DEM with points on a 1 foot grid
- A contour map (electronic) with 0.05' contour intervals or as otherwise requested
- An ASCII file with coordinates and elevations on all points in the grid
- A spreadsheet type report comparing elevations of validation points and DTM points
- A spreadsheet type report comparing elevations of validation points and raw data points

Scans for Accident Investigation

Due to the litigious nature of accident investigations and the possibility of the surveyor having to testify in court as to the accuracy of the scan and the methods used in performing the scan, standards of care for these types of scans will be established in the project specific scoping meeting on a project by project basis, based on the needs of the survey and the concerns of the surveyor in charge of the product.

Disclaimer

For projects contracted or performed under the administrative supervision of the Location & Surveys Unit, these standards are to be used on all pavement scanning projects unless the Locating Engineer or other representative of the Location and Surveys Unit specifies that other standards be used in the project specific scoping meeting. Any deviation from these standards should be reflected in the scoping minutes signed and dated by a representative of the Private Engineering Firm and by a representative of the Location and Surveys Unit.

Validation Point Report

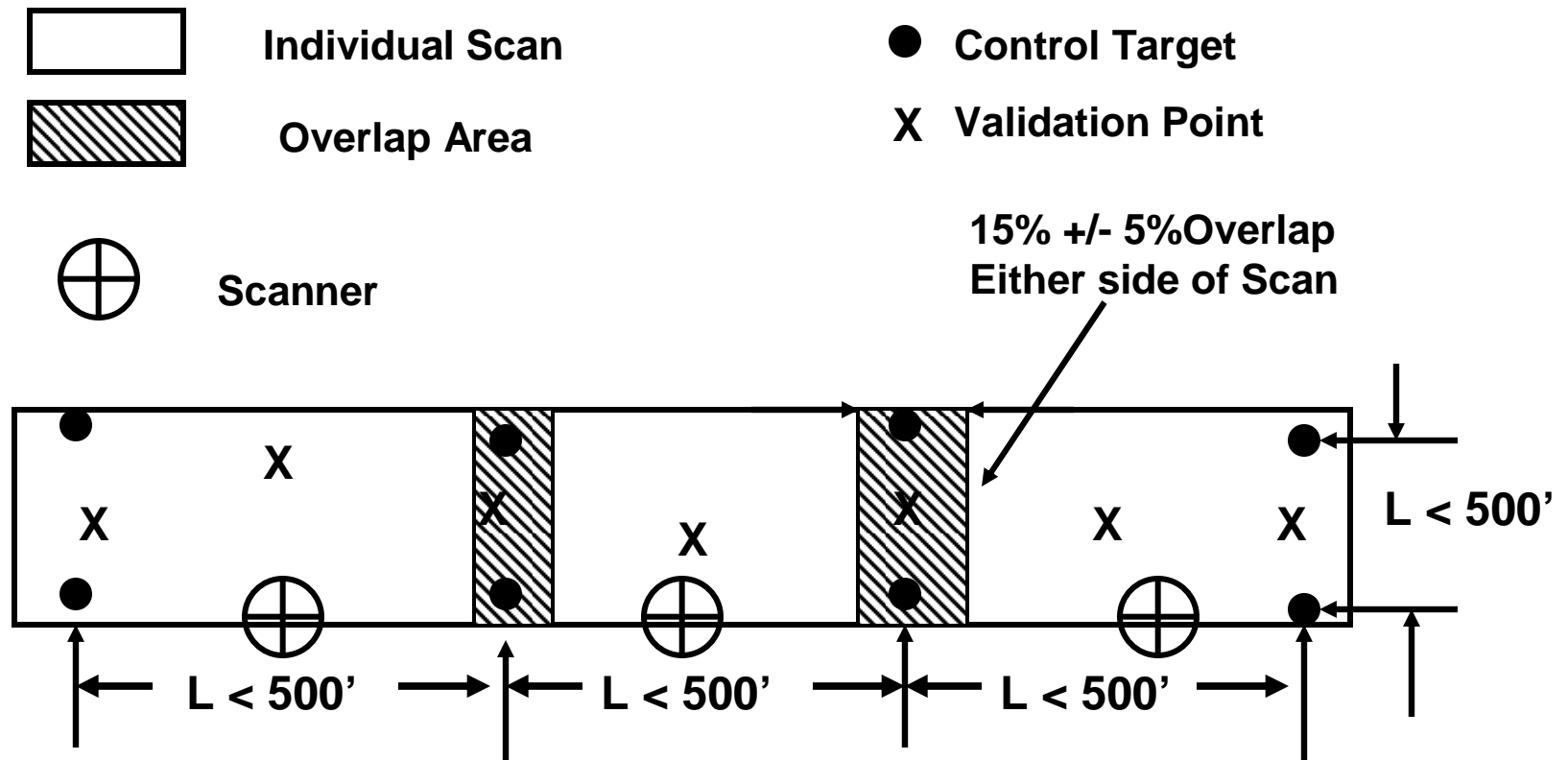
WBS Element
Division
Location
Survey Group
Date of Survey

Validation Point Number	North	East	Surveyed Elevation	DTM Elevation	Difference

Figure 2

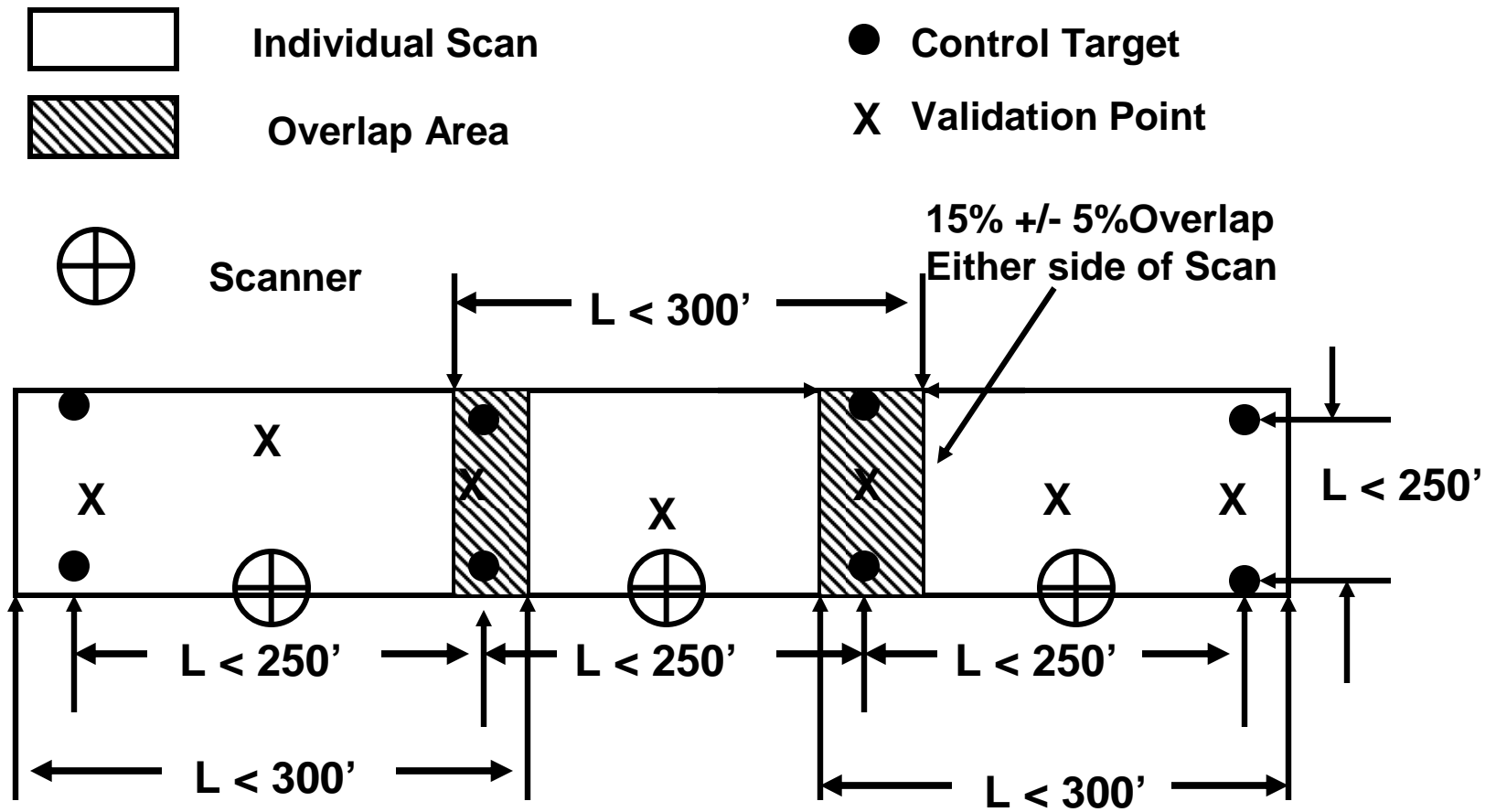
North Carolina Department of Transportation
HDS – Laser Scan Criteria

Figure 1 – Pavement For Design Surveys



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Figure 3 – Pavement For Resurfacing / Analysis



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Figure 4 – Pavement For Resurfacing / Analysis

