MINNESOTA DEPARTMENT OF TRANSPORTATION
OFFICE OF LAND MANAGEMENT
SURVEYING AND MAPPING SECTION
PHOTOGRAMMETRY UNIT

SPECIAL PROVISIONS FOR:

GROUP 3: DIGITAL TERRAIN MODEL/DIGITAL ELEVATION MODEL PRODUCTS AND SERVICES

DIGITAL TERRAIN MODEL COMPILATION
(DTM TYPE: "FINE"/ 1 FT. C.I.)

INTRODUCTION
This Specification is established to provide the Minnesota Department of Transportation (MN/DOT) with "Photogrammetry Products and Services" from Private Photogrammetric Partners (Contractor).

SCOPE OF WORK
These Specifications set forth the minimum standards to be met and general procedures to extract terrain information from aerial photography using stereo compilation. "Stereo compilation" is further defined as the preparation of large scale, photogrammetrically prepared engineering maps which will be used on MN/DOT's Microstation system for highway and structure design.

Specific photogrammetric services authorized by this specification include the following:
- Production of a Digital Terrain Model (DTM) that will support Detail Design activities for transportation projects (1' C.I.).
- The intent of this specification is to produce a digital terrain model that will be used as the basis for a "Surface TIN Model", capable of generating contours and/or cross-sections utilizing "GEOPAK" highway design software.

ITEMS PROVIDED AND/OR COMPLETED BY MN/DOT
Specific information to be supplied for each project includes the following:

- Work Order Contracts. Each Work Order Contract will include the following information:
    o Project designation or numbers.
    o Project location.
    o Project limits.
    o Units of measurement.
    o Coordinate Datum/Projection/Adjustment.
    o Match File Requirements.
    o Specific Project Deliverables.
    o Deliverables Schedule/Evaluation.
    o List of materials that will be provided by MN/DOT.
    o Special Requirements.
    o Start date.
    o Completion date.
    o Invoice, Incentive/Disincentive Schedule.
    o Total project cost payable to Contractor.
- Contact Prints/ Diapositives/Digital Images, if applicable.
- Mapping Limit Diagram.
- Project Seed Files.
- Mn/DOT Digital Map Symbols Manual.
- List of photo control points.
- List of analytical control points, if aero-triangulation solution is provided.

Please be advised: it is the Contractor's responsibility to provide safe storage and prompt return for all items supplied by MN/DOT. The Contractor is liable for lost or damaged items.

DELIVERABLES BY CONTRACTOR
Specific deliverables authorized by this specification include the following:

- Cost estimate for each project.

- Monthly progress reports.

<u>EVALUATION AREA</u>
- For: preliminary evaluation of terrain model structure, format and level placement.
- Test Area is due 7 calendar days from the start of terrain model compilation.
- The Contractor will provide the name and phone number of the primary contact person for the evaluation area.
- Specific Deliverables:
  - o 3D .DTM file (3D break lines, void area boundaries and mass points) of evaluation area (complete with a Boundary Polygon enclosing pilot area).
  - o diapositives of evaluation area.
  - o contact prints of evaluation area.
  - o aero-triangulation solution, if completed under Work Order Contract.
- Files may be delivered on diskettes or CD's.

<u>FINAL SUBMITTAL</u>
Materials to be provided after acceptable correction of compiled terrain model data, as directed by MN/DOT, if required.
- Approved terrain model files in Microstation .DGN Graphics File format. <u>Production and delivery of 100% clean, edited digital data in Microstation .DGN Graphics File format is required.</u>
- The DTM files will consist of 3D break lines, void area boundary lines and mass points. The Contractor is not required to submit a processed triangulated surface file, unless specified in the Work Order.
- A "File Limits Diagram" will be produced, showing the limits, boundary and name for each project file.
- Files may be delivered on zip diskettes or CD's.
- All point marked diapositives utilized as part of the project. Diapositives will be packaged and delivered flat.
- All contact prints, annotated with control data, which were utilized as part of the project. Contact prints will be packaged and delivered flat.
- Aero-triangulation solution, if completed under Work Order Contract.

<u>PERFORMANCE BASED SPECIFICATIONS</u>
All products and services authorized under this specification will be completed in accordance with the <u>MN/DOT MANUAL OF SURVEYING AND MAPPING, Chapter Four (current edition)</u>, the <u>MANUAL of PHOTOGRAMMETRY (Fourth Edition)</u> and the following performance specifications:

<u>UNITS OF MEASURE</u>
The default unit of measure is "English".

Files will be compiled with coordinate values to 1/1000 (ft).

Working Units for Microstation Design Files: Master Units – 1 FT.
                                                    Sub Units – 1.
                                          Positional Units – 1000.

Metric values shall be converted using the U.S. Survey Foot, if required.

<u>TERRAIN MODEL CONTENT/ FORMAT</u>
Digital Terrain Model (DTM) files are separate from mapping files and consist of 3D data in the form of line strings measured along surface specific features and terrain changes (breaks) and as discrete points (mass points).

BREAK LINES: Break lines are conceptual lines along which the slope of the terrain changes. Break lines delineate and portray seams on the surface and places where adjacent areas of constant slope change. Examples of

break lines include: ridge tops, ditch bottoms, top and bottom of road cuts, etc. Break lines are not contour lines; elevations may vary along break lines.

"Break Line" compilation will be in accordance with the <u>DIGITAL MAP SYMBOLS MANUAL</u>, provided by MN/DOT, and the following standards:
- Regular break lines will be recorded as a point line string on **level 15** of the digital map.
- Break lines must not cross other break lines.
- Break lines must snap to vertices on adjacent break lines when two break lines intersect.
- Break lines must not be placed closer together than 1' horizontally (at map scale).
- Elevation points along break lines must be dense enough to ensure that adjacent break lines do not cross and the nuances of the terrain is accurately portrayed or at a maximum spacing of 25', whichever is less.
- Break lines must not be compiled using any "stream digitizing" technique.
- Break lines must not terminate at roadway intersections. The break line must turn and follow the feature out along the intersecting roadway to the limit of mapping.
- For roadway features, break line compilation will include the following minimum standards:
    o Centerline of roadway.
    o Lane separations (for multiple lane roadways).
    o Edge of mainline pavement.
    o Shoulder P.I.
    o Bottom of ditch (a minimum of three break lines are required to define the ditch bottom).
    o Ditch back slope P.I.
    o For curb and gutter sections, break lines must be collected at the flow line and back of curb.
- For off-roadway terrain features, break line compilation will include the following minimum standards:
    o Ridge lines.
    o Rim of pits or significant depressions.
    o Areas of slope change or undulations in slope.
    o Bottom of valleys or draws.
    o Hydraulic features.
    o Around buildings and structures (including the top and bottom of walls).
- Break lines must not stop short of void areas or boundary polygons.
- Individual shots that define a break line along a tight radius curve must be dense enough to ensure that the triangles formed in the .TIN file to not cross over to adjacent break lines.
- Break lines in adjacent match files must intersect at coincident points (x,y,z).

Mass Points: DTM Point Elevations, or Mass Points, are discrete elevations that are used to complete the DTM surface after all break lines have been compiled. Mass points are intended to define the surface in areas of uniform terrain.

"Mass Point" compilation will be in accordance with the <u>DIGITAL MAP SYMBOLS MANUAL</u>, provided by MN/DOT, and the following standards:
- Mass points will be recorded as zero length lines on **level 13** of the digital map file.
- Mass points will be used to define the maximum and minimum elevations within the terrain model.
- Mass points will define the peaks and depressions on the DTM surface.
- The distance between mass points and adjacent mass points or between mass points and adjacent break lines will not exceed 25'.

Void Areas: include, heavy tree cover, deep shadows, water bodies, etc. (areas that can not be compiled within MN/DOT's accuracy standards).

"Void Area" compilation will be in accordance with the <u>DIGITAL MAP SYMBOLS MANUAL</u>, provided by MN/DOT, and the following standards:
- Void areas will be outlined with a closed break line called a "void area".
- Void area boundaries must be a closed shape single element.
- Break lines and void area boundaries must exactly intersect at common vertices (x,y,z).
- Surrounding break lines must not stop short of void areas or boundary polygons.
- Void areas must not overlap onto other void areas.

<u>ACCURACY STANDARDS</u>

VERTICAL ACCURACY**			
PHOTO SCALE	95%	100%	REPORTING METHOD
1" = 250'	<0.5' of true ground elevation	<1.0'of true ground elevation	NSSDA (tested by MN/DOT)
** Scope: elevations at "well-defined" points. Vertical accuracy of all DTM's will be tested by creating a "Geopak" .TIN file. The generated elevation will be compared to the ground surveyed elevation at the same X,Y location.			

PROCEDURAL BASED SPECIFICATIONS

All products and services authorized under this specification will be completed in accordance with the following procedural specifications and as directed by the Photogrammetric Engineer:

<u>GENERAL</u>
Where these specifications, the Work Order Contract and contract documents describe portions of the work in general terms, but not in complete detail, it is understood that only "Best Industry Practices" are to prevail.

<u>EQUIPMENT</u>
The stereo plotter(s) used to complete the project will be the instruments listed in the Contractor's proposal unless specific permission is granted by MN/DOT to use alternate equipment. Any mapping that is completed using non-approved equipment may be rejected and recompiled at the Contractor's expense, as determined by the Photogrammetric Engineer.

The Contractor will validate the calibration of each analytical stereo plotter within 30 days prior to the date of compilation.

<u>DATA FILE FORMAT/REQUIREMENTS</u>
All mass point data must be compiled directly in or translated to the Microstation Design File format, Microstation ver. 5.0 or higher.

Mass point data collected for digital terrain model generation will be done in 3D if compiling directly into Microstation Design File format.

Files will not exceed 15MB in size.

The global origin for the map files will be in the lower left corner of the design plane ((0,0,0) for 3D files).

"MN/DOT mapping file naming standard". The file name will be composed of two alpha characters, followed by the designated MN/DOT State Project (SP) number, followed by a period and three alpha characters designating the map file as planimetric mapping or DTM. The first character of the file ID will always be "P", followed by

alpha character "A" for the first file in the project and sequencing alphabetically through the files in the project. The last four characters will be ".PLN" for planimetric mapping or ".DTM" for digital terrain models. Example: PA021406.PLN (SP 0214-06) or PC278250.DTM (SP 2782-50).

The Contractor is required to keep a back up of all electronic files produced for the project for 1 year after final acceptance is made.

PRODUCTION TECHNIQUES
Digital data will be recorded directly as a function of stereo plotter operation. Prior approval must be acquired to compile on a digital workstation.

MN/DOT approval must be acquired before software generated or interpolated points are incorporated in the project.

All 3D terrain features will be identified with the following Microstation (5.0 or higher) 3D element types as appropriate: line, point, line string, or shape (no other elements such as arcs or curve strings may be used).

All DTM features must be snapped and matched exactly to adjacent map files and other project files provided by MN/DOT.

PROJECT EVALUATION/ ACCEPTANCE
Within seven calendar days from the start of map compilation, the Contractor will provide materials to Mn/DOT as specified in "Deliverables by Contractor". MN/DOT will evaluate level assignment, line codes, line weights and line structure. The Contractor may continue compilation while MN/DOT reviews the map file, however, the Contractor is responsible for all corrective action and modifications required.

Upon completion of project compilation and initial edit, the Contractor will submit the project to MN/DOT for review. MN/DOT will spot check the work and note items that require correction, if any (MN/DOT will not "flag" every item, only representative examples of corrective action required). The Contractor will make a concerted effort find and correct all features not meeting specifications.

MN/DOT will review the "Contractor's Final" delivered map files and will make all necessary edits to bring the project within specification. MN/DOT reserves the right to deduct monies, due to the Contractor, the actual cost incurred to bring a sub-standard project into specification. The cost of corrective action performed by MN/DOT is specified in the Special Conditions.