

APPENDIX O

DIGITAL TERRAIN MODEL PROCESSING CAPABILITY

The IGrds DTM processing capability allows for the extraction of terrain surface data from 3D design files, and provides for providing design surface data in a form readable by the CAiCE and InRoads DTM processes. The DTM processing capability only requires that a 3D design file with the DTM triangles be displayed. This allows any DTM vendor that can display the DTM triangles in a 3D design file to be compatible with IGrds.

Creation of surface models, and providing access to them, is the key function of any DTM system. Surface models are digital representations of actual surfaces, such as original ground surfaces, subsurface layers, designed surfaces or composites of original and design surfaces. Surface data is in the form of random points (X,Y,Z) and three dimensional strings. These data are compiled into surface models. In this type of model, all points and strings are formed into triangles which define the surface, with random points becoming triangle vertices and strings becoming sides of triangles. The IGrds DTM processing capability allows an “arms length” coupling with commercial DTM packages as only the triangles need be displayed in a 3D design file to be useful.

The chart below illustrates how IGrds and the Commercial DTM systems compliment one another.

IGrds	DTM
<ul style="list-style-type: none"> ◦ Extracts cross sections and profiles from displayed DTM surfaces using the IGrds DTM processing capability ◦ Uses cross sections and profiles to create design cross sections ◦ Compiles data for design surfaces for input to the DTM system (CAiCE and InRoads) 	<ul style="list-style-type: none"> ◦ Manages surface data input ◦ Compiles surface models ◦ Manages surface files ◦ Computes contours and other surface representations ◦ Produces MicroStation displays of surface and data properties for use by the IGrds DTM processing capability

DTM PROCESSING

The DTM extraction capabilities within IGrds provide a broad range of functions including the following:

- Extracting cross sections or profiles from any surface or any subsurface layer which is related to the surface.
- Attaching material designations and other data to subsurfaces (for use in multiple subsurface design and in displays).
- Extracting feature code data along with cross sections or profiles (i.e., at intersections with feature coded data lines).
- Filtering extracted cross section or profile data to eliminate superfluous data according to user criteria (see the cross section filtering discussion in the computation algorithm section of this Appendix).
- Flexible user control of cross section extraction specifications:
 - Surface or subsurface
 - Station
 - * by range and increment
 - * at specified individual stations
 - * at key points (PC, PT, TS, or ST)
 - * at listed stations
 - * at severe profile breaks
 - * at even stations only.
 - Width of sections
 - * by distance left or right
 - * as determined by geometric elements (lines, arcs, chains)
 - Filtering options
 - * offset
 - * elevation

- Output options in addition direct transfer to IGrds Station File
 - * RT-40 Terrain data set (includes Feature Code data).
 - * X, Y, Z ASCII File
 - * Displaying cross section lines as 3D elements.
- Flexible user control of profile extraction specifications:
 - Surface or surfaces
 - Along alignment and offset or geometry element
 - Filtering operations
 - * offset
 - * elevations

COMPUTATION ALGORITHMS

Profile Breaks

IGrds uses a "divide and conquer" approach to densify cross sections in the areas of severe profile breaks. The standard method of cutting cross sections uses an increment value and at every increment, a cross section is cut. A problem with this method is that between any two adjacent cross sections, the terrain may have a severe "break" and the earthwork volumes produced by IGrds will not take this into account. Cross sections have to be created at the severe breaks. IGrds solves this problem in the following fashion.

First, cross sections are cut using the standard method in which there is a cross section at every increment, say 100 feet.

Starting with the first (back) and second (ahead) cross sections, the two centerline elevations are connected by a chord and this chord is compared to the elevations returned by a DTM generated profile. At every point of the DTM generated profile between the back and ahead cross sections, the difference is measured running perpendicular to the chord. When that difference is greater than the maximum allowable deviation (entered by the user), the beginning point is marked and the rest of the DTM points are measured until the difference becomes less than the maximum allowable deviation. When this happens, the ending point is marked. A cross section is created at the maximum difference between the beginning and ending point range. The process starts again at the first (back) to the newly created cross section (ahead) and continues with the newly created (back) to the second (ahead) cross sections until the entire station range has been processed.

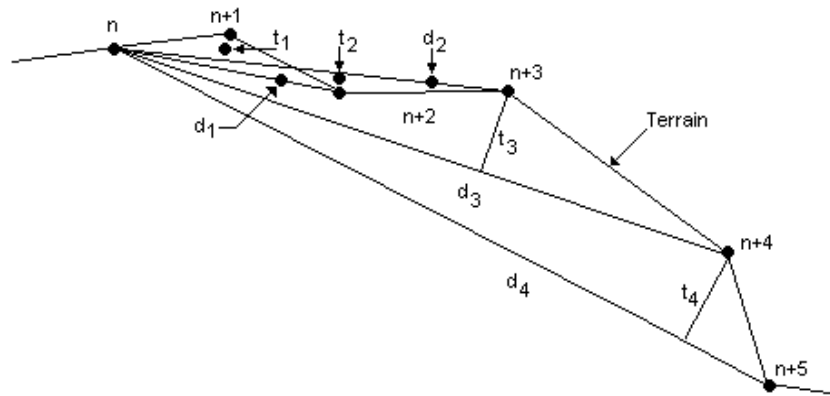
After the centerline elevations have been processed, the elevations of the left and right offsets (entered by the user) are compared against the DTM generated profile in the same manner.

With the divide and conquer approach, the user has the ability to determine the maximum allowable deviation value. This means that the IGrds profile generated by cross sections will not deviate any more than this value when measured (perpendicular to the cross section chord) against the DTM generated profile. The trade off is that the closer the IGrds profile is to the DTM generated profile, the more cross sections it takes to do this. This approach finds the minimum number of cross sections that are necessary to hold the maximum allowable deviation.

Cross Section Filtering

The IGrds cross section filtering algorithm uses the following logic:

- When terrain cross sections are generated from the DTM, the system is able to discard ("filter out") cross section points that are within a user specified vertical tolerance. The tolerance default is 0.2 feet for Imperial unit projects and 60mm for Metric projects, but the user has the option to enter any tolerance.



- Referring to the sketch above which shows a portion of an Imperial units terrain cross section, points are discarded as follows:
 - Given that $t_1 - d_1$, $t_2 - d_2$, $t_3 - d_3$, ..., $t_n - d_n$; and $t_1 \leq 0.2$ ft, $t_2 \leq 0.2$ ft, $t_3 \leq 0.2$ ft, $t_4 \leq 0.2$ ft; and point n is the beginning point (the first time through this process, $n=1$); then:
 - Points n+1, n+2, and n+3 are discarded; so, the new terrain path is a line from n to n+4; then:
 - Point n+4 becomes the beginning point and the above is repeated until the entire cross section has been processed.

- In addition to the tolerance above, the user has the ability to enter a horizontal distance tolerance. For example, if the user entered a horizontal distance tolerance of 10 feet and the horizontal distance between n+1 and n+2 was greater than 10 feet and the horizontal distance between point n+2 and n+3 was greater than 10 feet, then in the example above, point n+2 would not be discarded even though $t_2 \leq 0.2$ feet.

- The terrain cross sections generated from the DTM always contain the roadway centerline point (i.e., the roadway centerline cross section point is never discarded). Likewise, the first and last points of a cross section are never discarded.

See Figures O-1 and O-2 for an example of a filtered and an unfiltered cross section.

TEXA Baseline G
[Filtered 10 ft. H Tol]
[0.2 ft V Tol]

Filtered Cross Section

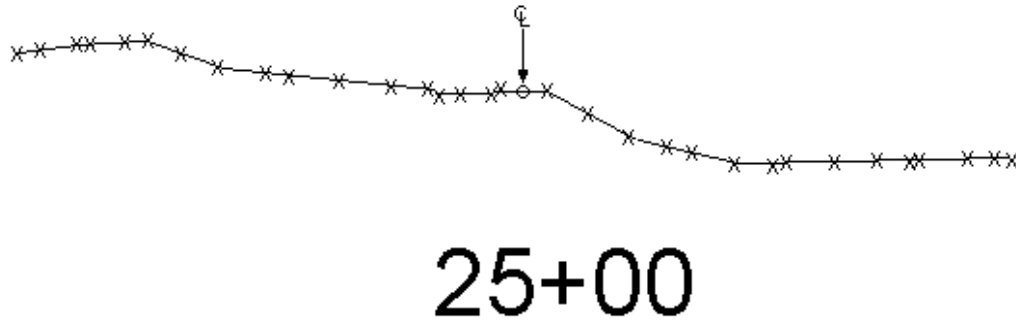


Figure O-1 - Filtered Cross Section

Original Cross Section
Produced by DTM

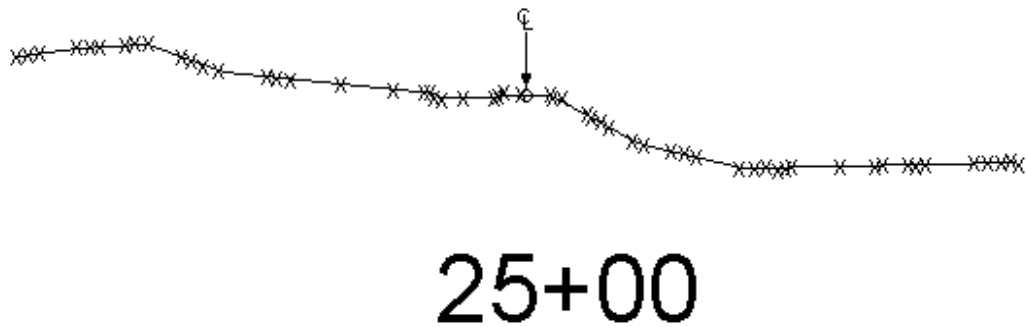


Figure O-2 - Non-Filtered Cross Section