Certainty 3D

March 4, 2011

To: General Release

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Re: TopoDOT™ Within the Point Cloud Process Workflow (#1007)

Background

This document presents TopoDOT™'s strategically important position within the overall point cloud and related data processing workflow, a description of functionality within the workflow and how that alignment of functionality and position maximizes productivity and value within your process.

Any software's relative position within the processing workflow is of fundamental importance to its value. Often the comparison of software programs with varying scopes of functionality and thus different relative positions in the workflow is a real source of confusion in the marketplace. Therefore in addition to the focus on TopoDOT™, this paper also offers a broader view of the workflow, principles and strategic approach to program selection that may aid in the assessment and comparison of any such processing program.

Overview of Process Workflow

The purpose of the "comprehensive" process workflow is to take lidar, image and survey data acquired by a system and ultimately produce a deliverable model containing information relevant to and meeting project requirements. There are many process steps between acquisition and deliverable covering a wide range of complexity and focus.

To begin, we note that the primary components of the system data set are typically comprised of, but not limited to:

- Point Clouds
- Images
- Network Control Data

As with many complex data sets there are a series of characteristic functions necessary to "process" the data from its raw sensor level form to more useable formats appropriate to the requirements of an end product. An overview of the typical basic functions employed in the processing of 3D Image data is given below.

1. System Calibration
2. Acquisition
3. Adjustment
4. Geometric Correction
5. Organization
6. Post-Acquisition QA/QC
7. Storage/Archive
8. Transfer
9. QA/QC
10. Feature Identification & extraction
11. Model Building

These steps are representative and will vary based on the technology and type of system. It should be noted that within the current market, the term "data processing" is frequently employed across this broad spectrum of functions. This single term applied to so many functions is often a cause of significant confusion. For example, "processing" for Geometric Correction is significantly different than "processing" for Feature Extraction.

The requirements of each function are sufficiently different as to preclude the practical development of a single software application applicable across too many of these functions. It is however, not unusual for the scope of a software application to extend over multiple functions.

Selecting the Optimal Process Software Application(s)

Prior to considering the software applications needed, it is imperative to assess your own operation and understand how and where your operational model fits into the overall process. If for example, your company owns a system, you should focus on the top level processes typically requiring the Low Volume/High Cost software solutions. If you intend to extract features and build models, you should consider a solution like TopoDOT™ in addition to your front end software. If you intend to only purchase data and process it, the downstream solutions like TopoDOT™ might prove sufficient.

Selecting the Optimal Processing Software

Certain process steps are confined primarily to the "front-end" of the process chain and are clearly tied more closely to the system itself. Functions such as System Calibration, Acquisition, Adjustment, and Geometric Correction are only performed one time per data collection.

Given their relative complexity and focus on front end processing at the system level, these programs will be predominately tied to individual systems. This complexity and limited application necessitates higher cost for such applications. Note also, that the technical trend is for these programs to be offered directly from the system manufacturer as these functions typically demand an intimate knowledge of the system itself for optimum performance.

Contrast these processing programs with downstream QA/QC, Feature ID-Extraction and Model Building programs. The functionality required is far different from that required in the early system level stages of processing.

One notes that data is produced by these 3D image systems is of large quantity with applications across the spectrum of operations. Thus a single system could conceivably create demand for many tens to hundreds of such downstream processing programs.

As illustrated below, we divide the process chain into "Front End" and "Downstream" functionality. One can think of the objective of Front End processes as preparing the raw data such as point clouds, images, etc. for Downstream Feature, Model and overall information extraction. Data at the transfer stage should ideally be certified, documented and "generic" in format so it may pass from Survey (typically) to the Engineering, Design, Construction and other operations.

Ideally such programs should be standardized, providing high performance and low cost in order to exploit the data throughout the downstream design, build and operations processes. Operation within a standard CAD environment is a definite plus.

System Calibration

Acquisition

Adjustment

Geometric Correction

Organization

Post-Acquisition QA/QC

Front End Software:

- **Low Volume Sales**
- **Higher Cost**
- **Tied Closely to System (often offered by system manufacturer)**
- **Tied Closely to Survey Operations**

Storage/Archive

Data Transfer

QA/QC

Feature Identification & extraction

Model Building

Down Stream Software:

- **Higher Volume Sales**
- **Lower Cost**
- **Not Tied to System**
- **Standardize Functions for All Data Sources**
- **Use Across All Operations-Survey, Design, Engineering, Construction, etc.**

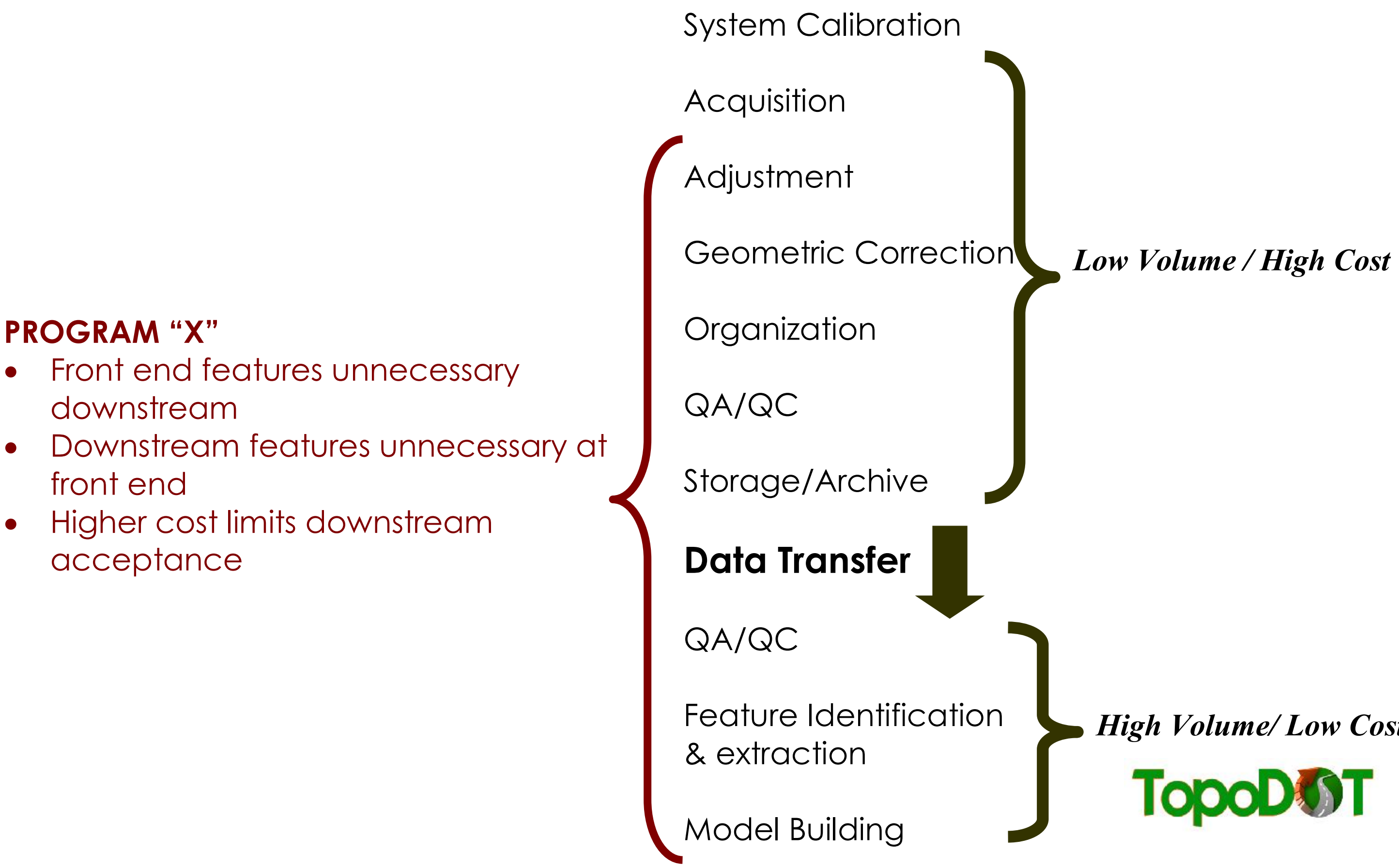
TopoDOT

Broad Application Software

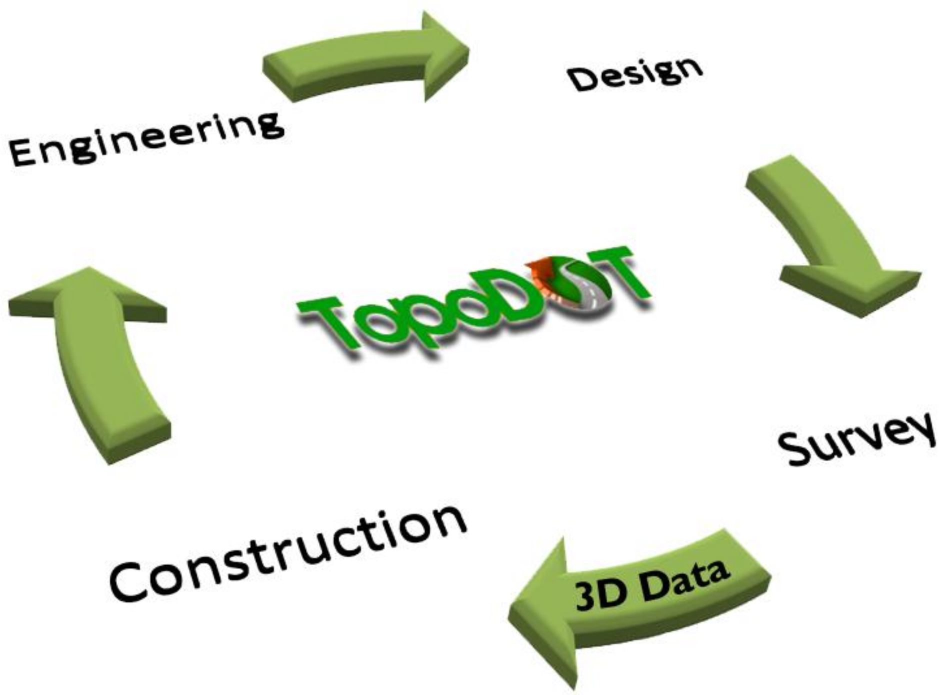
Contrast this software positioning within the process with a software solution attempting a broad application across the Data Transfer step. At first glance Program X might seem a "one stop solution". However closer analysis will show its lack of focus will potentially: 1) increase costs, 2) hinder use of data in downstream operations and 3) endanger data integrity.

Specifically, increased costs will result from carrying the complex front end processing functions across the Data Transfer stage where they are mostly irrelevant. This will add complexity and expense. Of course the ability to calibrate and (re)organize data in the downstream processes endangers data integrity with the threat of undocumented changes, adjustments, recalibrations, etc anywhere within the downstream operations.

Typically such high cost complex programs, especially those not functioning in a standard CAD environment, will not be adopted by the downstream processes within the engineering, design, construction, and other downstream operations.



To look at this another way, consider that TopoDOT™ is increasingly being used across all operations including survey, engineering, design, construction and management. These operations need a cost effective way to exploit the rich contents of point clouds, calibrated images, and survey data within their design environment in support of marketing, design-build, engineering, risk management among other activities. One can envision TopoDOT™ actually facilitating the "flow" of 3D image data across all operations.



By facilitating this flow of point cloud, images and related data across operations TopoDOT™ empowers anyone to identify, access and extract relevant information at their desk. Recent field operations results document increases in overall productivity of several hundreds to thousands of percent yielding substantial savings, increased margins and significant value.

In order to facilitate this data flow across operations, it is imperative that the downstream Feature Extraction and Modeling solution should:

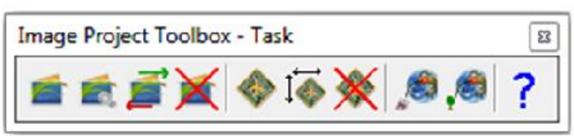
- Limit its focus to Feature Extraction and Modeling
- Function within a standard CAD environment
- Maintain raw data "integrity"
- Be intuitive and easily learned
- Feature flexible low cost license programs
- Maximize the value of 3D image data across operations

TopoDOT™ Function Summary

The preceding discussion focused on TopoDOT™'s position within the process chain and explained the reasoning and motivation behind its placement. Such an understanding will serve to clarify greatly the motivation behind the price, license program and functional capabilities of TopoDOT™. In this section we provide a summary of TopoDOT™'s functions for review. At any time this summary may be incomplete as new capabilities are continuously being added. However any new capabilities will remain consistently within the overall scope of TopoDOT™'s intended functionality and support strongly its placement within the process chain.

Images

Imagery is an increasingly important component of any 3D image data set. Specifically images calibrated and mapped to the point cloud data and extremely effective in the identification and extraction of features. TopoDOT™ offers a comprehensive tool set to import, display and map these images and point cloud data to common perspective views within the MicroStation CAD environment.



Tool	Function
Image Project	Creates image projects and allows manual image loading
Image Settings	Opens menu to change image distance and verticality display settings
Advance Images	Loads previous or next picture. For mobile system calibrated images.
Remove Image	Removes a loaded image in one or more windows
Load Aerials	Loads aerials from mainstream sources. Requires internet connection
Shift Aerials	Moves areal image to adjust to data
Remove Aerials	Removes loaded aerials
Scan Google Earth Export	Export images and scan positions information to Google Earth
GIS Google Earth Export	Export Shapefile and calibrated images information to Google Earth.
About	Information about TopoDOT

	Tool	Function
	Load Closest Image from Point	Load the closest calibrated image form a selected point
	Load Next Closest Image from Point	Load the second closest calibrated image form a selected point

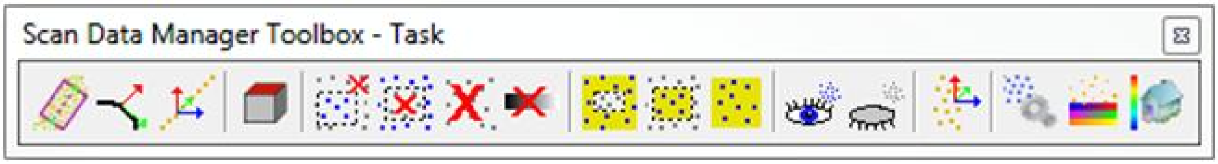
Point Cloud Project Management

The primary data component is typically the point cloud generated from a lidar system. TopoDOT™ offers a comprehensive set of management tools designed to import, classify, and select relevant point cloud data in an efficient and user-friendly manner. There are also a series of management functions designed to work efficiently within the constraints of your processor memory. These tools are so effective that TopoDOT™ places no practical limitations on the overall project size.

	Tool	Function
	Load Point Cloud From File	Loads a point cloud from a file. Supported formats are: .3DD .RXP .LAS .T3D .XYZ .PTS .CL3 .CLR
	Unload All Point Clouds	Creates data cross-sections perpendicular to an element at a specified registry
	Load Selected Mapped Positions	Loads point cloud data from selected position icons
	Load From Fence	Loads all data inside a fence within specified distance
	Point Cloud Manager	Enables the option hide, display and remove individual loaded point cloud files
	Mapped File Index	Lists registered position icon number with corresponding file name
	Map Position Icons	Maps position icons from positions registration
	Register Project Files to Icons	Identifies pointcloud files within the project structure and assigns an icon and a number to it. It links the position icon with its corresponding point cloud data file
	Register Scan Data From Folder to Icons	Identifies pointcloud files within a folder and assigns an icon and a number to it. It links the position icon with its corresponding point cloud data file
	LAS Parser	Divides large .LAS files in to smaller .LAS files by block size and or by number of points
	LAS Merger	Combines multiple .LAS file in to one
	LAS Flight Line Separator	Separates LAS file into multiple flight line
	Convert ASCII to LAS	Converts ASCII files to .LAS format without visualization

Scan Data Management

Subsequent to importing the relevant scan data (point cloud) TopoDOT™ offers another comprehensive tool suite designed to select, display that sub-selection of points within the current working point cloud. These user-friendly yet powerful tools present the operator with the desired scan data set in an easily understood and intuitive manner ideal for identifying and extracting features.



Tool	Function
Cross-section by Points	Creates data cross-section given a direction of the cut and a thickness
Cross-section by Element	Creates data cross-sections perpendicular to an element at a specified thickness
Cross-section by ACS	Creates data cross-sections in the ACS Z axis direction
Absolute Top View	Sets window to the absolute top view
Crop Points Outside Fence	Temporary removes data outside a fence from view
Crop Points Inside Fence	Temporary removes data inside a fence from view
Crop All Points	Temporally removes all loaded data points from view
Crop by Intensity	Temporally crops selected points with the same intensity values
Show Points Outside Fence	Displays cropped data points outside a fence
Show Points Inside Fence	Displays cropped data points inside a fence
Show All Points	Shows all loaded cropped data points
Show Point Cloud	Show all hidden data points
Hide Point Cloud	Hides all loaded data points from view
Fit ACS to Plane	Best fits the ACS to a plane of the visible points
Point Cloud Settings	Opens the data display settings dialog box
Colored Intensity Schemes	Opens a color scheme menu for color intensity display
Elevation Legend	Displays an elevation grid legend

Layers Management

It is often useful to classify points within the point cloud to "layers" in effect adding some intelligence to the raw point cloud data. For example a common layer assignment is "ground" classification. TopoDOT™ offers a comprehensive tool suite to select and assign point clouds to different layers. It also facilitates the import of points classified in other programs and the export of points within classified layers.

Tool	Function
Classify Inside Fence to Layer	Classifies points inside a fence to a selected layer
Classify Outside Fence to Layer	Classifies points outside a fence to a selected layer
Layer Visibility	Opens selection window to display hidden layer/s
Classify Ground to Layer	Enables the option hide, display and remove individual loaded point cloud files
Classify Points by Intensity	Lists registered position icon number with corresponding file name
Layer Settings	Maps position icons from positions registration

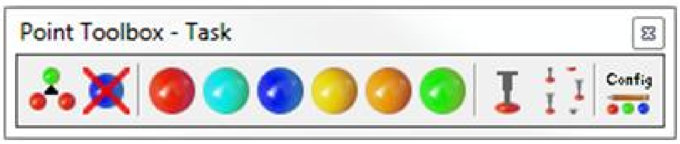
Main Processing

Identifying and extracting model features from the 3D image data set, point clouds and images, is primarily accomplished within the Main Processing Tool Suite. The form and function of these tools are based on years of experience extracting and building topographies and models from 3D image data sets.

Tool	Function
Road Extraction	At a specified step across the data profile and station spacing, it places spot shots, connecting lines thought the spot shots, peak point and crown points.
Break-line Generator	Used to create break-lines from up to four point nodes at specified intervals
Asset Identification	Places cells from a predetermined cell library at ground elevation
Elevation Grid	Places spot shots on hard surfaces or ground areas at specified interval
Railroad Extraction	Places line stings on railroad lines and center line by fitting preset standard rails profiles in specified intervals
Tunnel Profile	Creates tunnel profile at specified intervals
Drape Element to Data	Creates vertices on a element at proper data elevation to create a new element that fits the data at specified intervals
Drape Element to Intersections	Adjusts element to intersecting elements elevations.
Control Point to Data Analysis	Selects control points from corresponding level and compares their elevation to the surrounding point cloud to determine if points are within control tolerance. Provides full analysis and individual point visualization.
Plane Deviation	Provides a grid of points with distance deviation value from pointcloud surface to a plane
Feature Code Export	Used to export point and line coordinates and features in text format

Point Toolbox

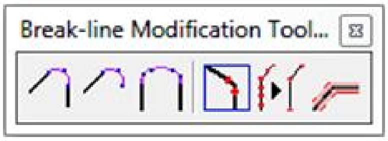
One of the fundamental functions of feature identification and extraction is the placement of a point at the correct spatial coordinate. TopoDOT™ offers a comprehensive and extremely useful tool suite focused on just this function.



Tool		Function
	Place Center Point	Places center point linearly between two points
	Delete All Points	Deletes all points in a unlock levels
	Place Red Point	Places a red construction point
	Place Teal Point	Places a teal construction point
	Place Blue Point	Places a blue construction point
	Place Yellow Point	Places a yellow construction point
	Place Orange Point	Places a orange construction point
	Place Green Point	Places a green construction point
	Place Survey Point	Places point with feature code text. Coordinates and feature code are exported In a .CSV file
	Update Survey Points CSV	Updates .CSV file from new survey point placement or changes
Config	Point Options	Construction point options to select level and locking plane placement

Break-Line Modification Tool

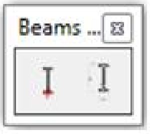
A primary feature extracted from the 3D image data set is the breakline. The breakline identifies a boundary of sorts where for example the elevation change over a surface changes direction quickly. Subsequent to extracting breaklines within the Main Processing tool suite, TopoDOT™ offers a tool collection focused on constructing, joining, and/or completing breaklines into homogeneous elements. These tools are extremely productive in coordinating and organizing the extracted breakline features into a unified topography and/or model.



Tool		Function
	Fit Arc (Two Lines One Point)	Creates a perfect 3D arc between two tangent lines and one median point
	Fit Arc (One Line Two Points)	Creates a perfect 3D arc between one tangent line and two consecutive points
	Fit Double Arc	Creates two perfect 3D arc between to tangent lines and on median point for each arc. Median line must be mutual for both arcs.
	Create Continuous Element	Joins coincident elements of the same level in a complex chain
	Element Key Points	Identifies key points vertically and horizontally to reduce the number of nodes and maintain the line geometry
	Fence Along Element	Creates a fence along an element of the specified thickness to both sides of the element

Beam Tools

TopoDOT™ within MicroStation environment facilitates the extraction of any 3D arbitrary element from the data set. There are of course some features such as I-beams which are standardized and consistently appear within such data sets. Thus TopoDOT™ offers tools focused on a very accurate extraction of these specific structures.



Tool		Function
	Beams	Creates a beam profile based on point cloud beam measurements
	Search Beam Standards	Searches though beam standards based on point cloud beam measurements to find a relevant size

Power Line Tools

Similar to the case with I-beams, the identification and extraction of features associated with power lines continuously arises within data sets containing outdoor infrastructure. TopoDOT™ offers a very focused tool set facilitating but not limited to extracting features, developing models, measuring, identifying spatial incursions and conflicts within right of ways as well as many more useful relevant functions.

Tool		Function
	Power Lines Extraction	Open power lines creation function window
	Power Lines Encroachments	Opens power lines encroachments function to identify clearance distance

Piping Toolbox

Conduits, piping, and piping features such as valves, flanges, etc., are often contained within infrastructure 3D image data sets. TopoDOT™ offers a complete tool set designed to identify and extract these features easily and accurately.

Fit Cilinder		Function
	Fit Cylinder to Data	Fits a conical element to scan data visible
	Pipe Fitting	Creates fitting between two conical pipes given the elbow radius
	Piping Features	Uses the pipe features cell library to place common standard pipe features over piping structures
	Place Flange	Place a user defined size flange to a pipe axis

Digital Terrain Model (DTM)

Upon review of the function summary, one might note the absence of any specific TopoDOT™ capability to generate a digital terrain model (DTM) from the features extracted using TopoDOT™. As the question of DTM generation often arises we address it here.

Note that this absence of a DTM generation tool is "intentional". In fact, DTM generation within TopoDOT™ is unnecessary and would be counterproductive for the following reasons.

There is no requirement for a DTM Tool within TopoDOT™
Every design program, such as GeoPAK, InRoads, Civil3D, etc. offers DTM generation. Breaklines and points extracted from 3D image data using TopoDOT™ are easily and effectively used as input to the DTM generation tools of each of these programs. So there is no immediate requirement for a DTM tool in TopoDOT™.

DTM incompatibility across design software platforms
DTMs generated by one program are typically not compatible with the downstream tools of another program. How the DTM is generated, organized, stored in memory, etc. is program specific and thus often not directly compatible with tools of another program environment. For this reason, any DTM generated by TopoDOT™ would have the inherent requirement of compatibility with all downstream design programs such as GeoPAK, InRoads, Civil3D, etc. Since this is not practical or probably achievable, it is best to limit TopoDOT™'s modeling capabilities to breakline and point extractions that are "easily" used as the inputs to DTM generation tools in all downstream design software applications.

TopoDOT™ scope and focus
As discussed, the position of TopoDOT™ within the overall processing chain has been optimized for maximum productivity and effectiveness. Generation of any DTM would quite assuredly generate customer requirements for functions such as volume calculations, contour extractions, etc. These functions are beyond the scope of TopoDOT™ and are already executed extremely well in downstream design software applications. Simply stated, TopoDOT™ is designed to extract the features from point clouds, calibrated imagery and general survey data necessary as input to the processes of practically all downstream "design" programs.

Summary

TopoDOT™'s position within the overall data process chain serves to keep costs down, avoids duplication of processes and maximizes overall productivity. The functionality of TopoDOT™ is clearly aligned with its scope and placement within the process chain. Within the data import/deliverable export boundaries of TopoDOT™ lay an extremely wide ranging and comprehensive collection of functions designed for maximum productivity and high quality generation of topographies, models and other deliverables.

This document is offered to assist in the comparison and evaluation of TopoDOT™ and other software applications designed for 3D image data processing. While the focus is clearly on TopoDOT™, the principles of position within the overall process, market requirements with respect to quantity and price as well as other themes are generically applicable in the evaluation of any software application.

Please contact Certainty 3D with any other specific questions, comments or suggestions.

Questions and/or Comments

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