



Certainty 3D

October 1, 2013

To: General Release

From: Mauricio Terneus
Certainty 3D, Inc.

Re: TopoDOT “Open” Calibrated Image File Format V.2(#1009)

Background

The TopoDOT® application offers the capability to import calibrated images and map the image pixel orientation to the perspective view of the selected MicroStation™ view. This unique tool makes it possible to overlay extracted CAD elements over the image in the selected view with very high precision thereby employing this image information as a reference in feature identification.

TopoDOT® places specific requirements on the calibrated image if this feature is to be successfully employed. These requirements can be summarized briefly as:

- Camera/Lens model (unique to each camera/lens pair for best results)
- Camera Location (project coordinates for each image)
- Camera Orientation (defined with respect to project reference frame)

The responsibility for providing the tools necessary to extract this information lies with the system manufacturer. The operator should follow manufacturer’s process procedures necessary to acquire this data efficiently and accurately.

Certainty 3D will cooperate with any manufacturer to import their specific file formats. As increasing numbers of manufacturers add such calibrated image capability to their systems or individual operators attempt to develop their own solutions, Certainty 3D has seen a need for an “open” format to support our customers and the industry.

This document identifies and explains the file format necessary for effective application of this unique TopoDOT® feature.

Camera/Lens Model

The format describes the camera/lens model as well as associated metadata describing file directories, units, camera identification, etc. Note that currently Certainty 3D has experience with and can offer calibration services for the Nikon D300 and D700 cameras. We recommend Nikon 20mm lens to facilitate the widest range of applications. Certainty 3D can then provide the camera/lens calibration model for these specific camera/lens pairs.

Certainty 3D will accept other cameras but the can not at this time offer calibration services. In this case, the operator will be responsible for supplying the camera calibration model for his specific camera/lens pair.

Image Project File (.iprj) - Version 2*

```
[Image Project]
Version=2
Units=sf
RotationOrder=1

CameraCount=1
Name0=Camera 1
ImageDirectory0=.
CalFile0=.camera1.cal
```

[Image Project] – Header required for the file.

Version – Current version of the file format.

Units – Units in which the coordinates are specified in the image project.

Valid values are:

- sf – Survey Feet
- f – Feet
- m – Meters

RotationOrder – Order in which the heading roll and pitch will be multiplied.

Valid values are:

- 1 – Heading * Pitch * Roll
- 2 – Heading * Roll * Pitch
- 3 – Roll * Pitch * Heading
- 4 – Pitch * Roll * Heading

CameraCount – If multiple camera calibrations are available, set this value to the total number of cameras in the project. For each Camera, there must be a Name and CalFile associated with it.

Name(index) – Name of the camera calibration

ImageDirectory(index) – Each calibration file may contain a unique directory. This directory is a relative path from the location of the image project file to the directory where all of your images are located.

CalFile(index) – Relative path from the location of the image project file to the location of the camera calibration file.

Camera Calibration File (*.cal) - Version 2

```
[Calibration]
Version=2
Type=1
dx=8.4E-6
dy=8.4E-6
Nx=4256
Ny=2832
fx=1689.97897707826
fy=1691.03752169727
Cx=2122.84859490073
Cy=1432.31598208073
k1=0.00403931369502396
k2=-0.0754263253765206
k3=-0.0852103024783204
k4=0.121648640543892
P1=-0.00028428014657276
P2=8.05378517964374E-5
```

[Calibration] – Header required for the file.

Version – Current version of the camera calibration file.

Type – Type of Lens used. Valid values are:

- 0 – Normal Lens.
- 1 – Fish Eye Lens

dx – Dimensions of a single pixel of the CCD sensor in meters. Value is typically specified by the manufacturer.

dy – Dimensions of a single pixel of the CCD sensor in meters. Value is typically specified by the manufacturer.

Nx – Number of pixels in the horizontal direction.

Ny – Number of pixels in the vertical direction.

fx – Focal length in the x direction. The parameters fx are normalized by the pixel size.

fy – Focal length in the y direction. The parameters fy are normalized by the pixel size.

$$f_x = \frac{f}{d_x}$$

fx.....[pix]

f.....focal length [m]

dx.....[m]

Cx – Principal point in the x direction.

Cy – Principal point in the y direction.

k1 – Radial distortion coefficient.

k2 – Radial distortion coefficient.

k3 – Radial distortion coefficient. Used for higher-order modeling of the radial distortion.

Value of 0 is valid.

k4 – Radial distortion coefficient. Used for higher-order modeling of the radial distortion.

Value of 0 is valid.

P1 – Tangential distortion coefficient.

P2 – Tangential distortion coefficient.

Camera Location/Orientation

The image list file contains all images tagged with the camera location, orientation and ID as shown below. It is important to note that the camera location must be located in the overall project coordinate system. Similarly, the orientation must be referenced to the project coordinate axes. In addition to this information a detailed description including rotation order should be supplied as documentation of this format.

Some manufacturers may provide Certainty 3D with transformation matrices within their project file designed to place the camera in the correct position and orientation. Certainty 3D will work with these manufacturers to import their data seamlessly into TopoDOT. However the following file format will achieve seamless integration as given.

Image List File (.lst) - Version 1*

```
[Image List]
Image=DSC_0044.JPG
Xyz=0.0 0.0 0.0
Hrp=0.0 -90.0 -2.5
Camera=0
```

```
Image=DSC_0045.JPG
Xyz=0.0 0.0 0.0
Hrp=45.0 -90.0 -2.5
Camera=0
```

```
Image=DSC_0046.JPG
Xyz=0.0 0.0 0.0
Hrp=90.0 -90.0 -2.5
Camera=0
```

[Image List] – Header required for the file.

Image – Filename for the image.

Xyz – Coordinates to the center of the camera at the moment the image was taken.

Hrp – Heading, roll, pitch orientation of the camera at the moment the image was taken.

The following information holds true:

Heading (Rotation around Z axis)

Roll (Rotation around X Axis)

Pitch (Rotation around Y Axis)

Hrp=0.0 0.0 0.0 **image vector pointing straight up.**

Hrp=90.0 0.0 0.0 **image vector pointing straight up, rotated 90 degrees.**

Hrp=0.0 90.0 0.0 **image vector pointing South**

Hrp=0.0 0.0 90.0 **image vector pointing East.**

The order that these rotations happen will depend on the RotationOrder variable in the .iprj file.

The final transformation should provide the following result:

http://www.certainty3d.com/pdf/technotes/OpenImageFormat_ImageOrientation.jpg

Camera – Index for the camera calibration to use for the image.

Please contact Certainty 3D with comments, critiques, and/or recommendations.

Questions and/or Comments

Please contact:

Author: Mauricio Terneus
Certainty 3D, LLC
7039 Grand National Drive, Suite 100
Orlando, FL 32819
Tel: 407-248-0160
www.certainty3d.com