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# ContextCapture

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User Guide



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# Table of Contents

---

<b>Chapter 1: Welcome .....</b>	<b>7</b>
What's New? .....	7
Installation .....	10
Configuration .....	11
Licensing .....	12
Useful concepts .....	15
<b>Chapter 2: Preparing the Imagery Dataset .....</b>	<b>17</b>
Photo acquisition .....	17
Input data file formats .....	19
Positioning data .....	20
<b>Chapter 3: ContextCapture .....</b>	<b>21</b>
Principle .....	21
Capturing close range - mid range subjects .....	22
Mapping large-scale urban or natural environments .....	22
Architecture .....	23
Workflow .....	25
System Requirements .....	25
About Remote desktop connection .....	26
About Windows session .....	26
About paths with non-ASCII characters .....	26
Performance .....	26
Software Editions .....	27
Interoperability .....	28
CAD/3D Software .....	28
2D/3D GIS software .....	29
3D Visualization .....	29
Web publishing .....	29
<b>Chapter 4: ContextCapture Master .....</b>	<b>30</b>
Project .....	31
General .....	32
Options .....	34
Reference manager .....	35
Basemap manager .....	38
Free Up Disk Space .....	45
Block .....	45
General .....	47
Photos .....	48
Point clouds .....	54
Surveys .....	58
Block 3D view .....	72
Additional data .....	86

Aerotriangulation .....	87
Process on the cloud .....	100
Import video frames .....	100
Import photo positions .....	102
Import blocks .....	108
Import surveys data .....	109
Split block .....	109
Extract block .....	112
Export .....	114
Share on ProjectWise ContextShare .....	117
Load/unload blocks .....	117
Merge blocks .....	118
BlocksExchange XML/XMLZ format .....	119
MS Excel block definition .....	127
ATExport XML format .....	128
Camera database .....	129
Reconstruction .....	134
General .....	136
Spatial framework .....	137
Geometry constraints .....	141
Reference model .....	142
Processing settings .....	144
Touchup .....	149
Reset .....	154
Inter-tile color equalization .....	155
Tile selection .....	156
Production .....	158
Creating a new production .....	159
Production processing .....	161
Output formats .....	161
Extent .....	175
Share .....	175
Geometry constraints/Surface water detection (Technology preview) .....	175
Process on the cloud .....	176
General .....	176
Properties .....	178
3D View .....	178
Job Queue Monitor .....	179
ContextCapture cloud processing service .....	180
Web publishing .....	181
Share on ProjectWise ContextShare .....	181
Publish with ContextCapture Web Viewer .....	183
Publish to Cesium or ContextCapture Web Viewer 2.0 .....	185
Publish to Sketchfab .....	186
Retouching .....	187
Spatial reference system .....	192
Spatial reference system database .....	192
Vertical coordinate system .....	194
User defined system .....	195
<b>Chapter 5: ContextCapture Engine .....</b>	<b>198</b>

<b>Chapter 6: ContextCapture Viewer .....</b>	<b>200</b>
<b>Chapter 7: ContextCapture Web Viewer .....</b>	<b>202</b>
<b>Chapter 8: Convert 3MX to Scalable Mesh .....</b>	<b>204</b>
<b>Chapter 9: ContextCapture S3C Composer .....</b>	<b>205</b>
ContextCapture S3C Composer Main Interface .....	206
Export instant loading scene file .....	208
<b>Chapter 10: ContextCapture Target Creator .....</b>	<b>212</b>
<b>Chapter 11: ContextCapture .....</b>	<b>214</b>
<b>Chapter 12: Job Monitoring .....</b>	<b>215</b>
<b>Chapter 13: ContextCapture camera model .....</b>	<b>217</b>
About this document .....	217
Equations of the camera models .....	217
Perspective camera model .....	217
Fisheye camera model .....	219
<b>Chapter 14: ExportUniqueMesh: post-processing tool for generating city-scale 3D models with complete level-of-detail structure .....</b>	<b>221</b>
Introduction .....	221
Summary .....	221
About this document .....	221
Motivation .....	221
Usage .....	222
Example Usage .....	222
Command-line syntax and allowed options .....	222
Documentation .....	224
Output .....	225
Formats .....	225
Level of Detail Structure .....	226
Legacy format .....	227
<b>Chapter 15: 3MX Web Deployment .....</b>	<b>229</b>
How to produce for web viewing .....	229
The web format .....	229
The production options .....	230
The production reference system .....	231
The production result .....	232
How to configure the web application and scene .....	234
Configuring the 3MX .....	235
Configuring the web viewer .....	237
How to deploy the production .....	241
How to view locally .....	241
Deploy on the internet .....	242
The ContextCapture Web Viewer Interface .....	244
Navigation .....	244
Rendering .....	247
Measurements and GIS positioning .....	248

Link to the model .....	251
More information .....	253
Appendix A: View the ContextCapture Web application locally .....	253
Change local files security policy .....	254
Run local server .....	255
<b>Chapter 16: 3D multiresolution Mesh eXchange format (3MX) .....</b>	<b>257</b>
3D multiresolution Mesh eXchange format (3MX) Introduction .....	257
Level of detail principles .....	257
3MX format .....	260
3MX file .....	260
3MXB file .....	263
Current implementation .....	268
3MX Export .....	269
3MXB export .....	269
About Spatial Reference System .....	270
Pointclouds Technical Specifications .....	270



ContextCapture is developed by [Bentley Systems](#), the leading company dedicated to providing comprehensive software solutions for sustaining infrastructure.

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ContextCapture Basic Edition automatically reconstructs objects, buildings, man-made or natural landmarks, from imagery datasets of up to 50 gigapixels. Most suited for, but not limited to, UAS /UAV/drone operators, this edition allows the production of high resolution 3D models as well as the generation of digital surface models (DSM) and true orthophoto.

## What's New?

### Update 18

- Job Queue: possibility to change AT and Reconstruction jobs priority from the user interface and from the SDK.

# Welcome

## What's New?

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- Job Queue: job queue management API no longer requires a license.
- Aerotriangulation: unified AT engine combining the legacy standard engine and legacy alternate engine.
- Aerotriangulation: new preset to trigger legacy standard engine and legacy alternate engine.
- Aerotriangulation: improved support of GCPs to avoid breaks in the AT.
- Production: new Spatial 3D Model (S3M) format for compatibility with Supermap GIS software.
- Reconstruction: orthophoto engine is 20% faster.
- Reconstruction: Support of LAS version 1.3 & 1.4.
- Insights: ContextInsights automatic detection capabilities using Machine Learning are now integrated in ContextCapture.
- Insights: ContextInsights annotations are displayed in the 3D view.
- Interface: thermal and resolution measurements on mesh now displayed in the new 3D view.
- Interface: survey point names are now displayed in the 3D view.
- Interface: scan names are now displayed in the 3D view.
- Interface: ContextCapture Cloud Processing Console installer is no longer embedded in ContextCapture installation.
- Interface: icon to tell if survey points are user-tie points, GCPs or check points.

### Update 17

- Speed up of reconstruction (20% to 40% speed gain depending on projects).
- Aerotriangulation: use positioning metadata during matching to improve robustness.
- Aerotriangulation: improved robustness for rig setups.
- Aerotriangulation: improved handling of disconnected components.
- Upload/Download point clouds as PWCS ScanCollection.
- JobQueue revamp: improved job queue performance (now based on a database).
- Block 3D view/touchup UI measurement tools update/improved UX.
- Add the possibility to use point clouds in orthophotos.

### Update 16

- New Touchup tools.
- New alternate AT engine available as Preset.
- New 3Dmesh format "OpenCities Planner".
- New Block Export to Orbit 3DSM.
- New function to merge tiled orthophotos and DSM.
- Quality Control UI now available in ContextCapture edition.
- New Reference Manager. Enabling cloud synchronization of Image Collections and updated reference manager UI.
- Optimized reconstruction for vertical structure captured following orbit path.
- Speed up of reconstruction (average 20% speed gain).

### Update 15

- New orthophoto workflow based on dedicated reconstruction type, including a new texturing algorithm that greatly improves the visual quality.
- New aerotriangulation positioning mode management; enhanced control over adjustment and rigid registration steps.
- Revamped block 3D view with new user interface and tools, including lock on photo, quality metrics, editing tools for tie points, full resolution photo display, grid display, etcetera.

# Welcome

## What's New?

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- Automatic detection and generation of water constraints, available in a dedicated production (Technology preview).
- Block Import tool extended to ProjectWise ContextShare.
- SDK now included in the ContextCapture edition.
- New capability of merging point clouds into a unique LAS or POD file.
- Automatic control point registration extended to include compact tags.

### Update 14

- ContextCapture Cloud Processing Console embedded in the installer.
- New function "Process on the cloud" to ease project migration on the cloud.
- Processing time report on productions.
- New Share dialog to manage publication to ProjectWise ContextShare, and new formats supported for sharing (OBJ, LAS/LAZ, FBX, POD, Orthophoto/DSM, DGN, ESRI SLPK).

### Update 13

- Scan import now supports scans with unknown unique source position (auto detection of source position) and POD format.
- New types of tags supported for target autodetection: Chili Tags and April Tags.
- New quality metrics in block 3D view (camera and survey points colorization according to error, distance to input position).
- Improved performance and robustness of multipass aerotriangulation (now by default).
- Other bug fixes and improvements.
- ContextCapture Insights EAP.

### Update 12

- Splats: new textured 3D representation of tiepoints; available in a block after aerotriangulation.
- New compressed block exchange format XMLZ.
- Added support for mobile scan format NavVis PLY.
- Support of local coordinate system with known unit (for all production workflow from scale constraint, control points, etcetera.).
- Photo Navigation, a new block 3D view mode.
- Grid computing now supported in ContextCapture edition (limited to 2 computers).

### Update 11

- New licensing system based on Bentley CONNECT licensing.
- Upgraded internal component Bentley Powerplatform.

### Update 10

- Hybrid registration photos/point clouds: new aerotriangulation positioning modes to register photos using point clouds.
- New Surveys user interface with enhanced ergonomics and user assistance.
- Multi-scale constraints.
- Coverage map (Quality report).

### Update 9

- Production clipping based on region of interest
- New MasterKernel SDK packaging with python wheel

# Welcome

## Installation

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- New block type "Orbit" to optimize processing of scenes made of orbital views around a thin structure (cell tower, pylon, wind turbine, etc.)
- Improved quality report/acquisition report (side views, distance to input positions, uncertainty ellipses, color flags, expandable sections...)
- New reconstruction setting: texture source priority
- New production option: texture sharpening
- Surveys: new import wizard, added support of Propeller format
- Region of interest import from DGN format
- New web application ContextCapture Web
- Viewer 2.0 for Cesium productions

### Update 8

- Photo multiselection in the block's 3Dview (shift/ctrl keys, rectangle, by tie point).
- Faster Aerotriangulation and reconstruction.
- Measurements in US survey feet (new unit system settings).
- Survey points multiselection (for deletion/editing).
- New camera orientation option for block XML export.
- Enhanced aerotriangulation report.
- Extended/improved LOD production across tiles: now supports any kind of tiling (3D, adaptive tree, etcetera).
- New reconstruction settings to use only point clouds for geometry.
- Surveys data import/export including control and user tie points with measurements and positioning constraints.

[beta] New Aerotriangulation preset dedicated to fine structures (eg. telecom towers, pylons).

- Spatial reference system support for touchup and reconstruction constraints.
- New production 3D view tab.
- Surface/Volume measurement.
- Export of 3D mesh with texture and level-of-detail to GoogleEarth KML.
- Export of orthophoto to KML super-overlay.
- Interoperability with Bentley platform: Pointools POD, 3MX support in MicroStation Connect.
- Block merging (ability to merge two existing blocks from the user interface).

For more details, view the full changelog (doc/ContextCapture ChangeLog.txt) in ContextCapture installation directory.

## Installation

ContextCapture does not require administrator rights to run, however you must have administrator rights to install the application.

To make sure you have the latest version go to [www.bentley.com](http://www.bentley.com) and log in to gain access to the installer downloads. If you have not done so before, you will need to register on the website when prompted.

Once you have downloaded the installer, simply double-click on the downloaded package and follow the installation instructions.

Once you have downloaded the latest installer, simply double-click on the downloaded package and follow the installation instructions.

# Welcome

## Configuration

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⚠ For cluster users: please make sure to install the same version of your ContextCapture edition on all PCs of your cluster in order to avoid unsupported conflicts.

⚠ Installing a new version may break job compatibility. Jobs submitted before the installation of the new version may fail. You can simply re-submit the corresponding processings from ContextCapture Master to solve this issue.

## Configuration

### Job queue

ContextCapture Master and ContextCapture Engine use a master-worker pattern which is based on job submissions in a job queue directory.

ContextCapture Settings allows to set the job queue directory on a computer. When ContextCapture Engine starts, it reads this setting and dedicates to the corresponding job queue directory. When ContextCapture Master starts, it reads this setting and assigns the corresponding job queue directory to the new projects. Please note that the job queue directory of existing projects is not affected by ContextCapture Settings. Instead, it can be modified from the [Options](#) (on page 34) tab in ContextCapture Master.

[Managing the job queue](#) (on page 215).

### Internet access

ContextCapture requires internet access to activate your license and your account, manage software updates, to access Bentley Geocoordination Services, or to directly publish 3D models on the web.

You can configure the connection according to your proxy settings.

## System information

From ContextCapture Settings, you can get a system information summary from the *System information* tab.

In case of technical problems with the software, the technical support team may ask you for information about your system. Use this tool to get a system report and send it to the technical support team.

# Welcome

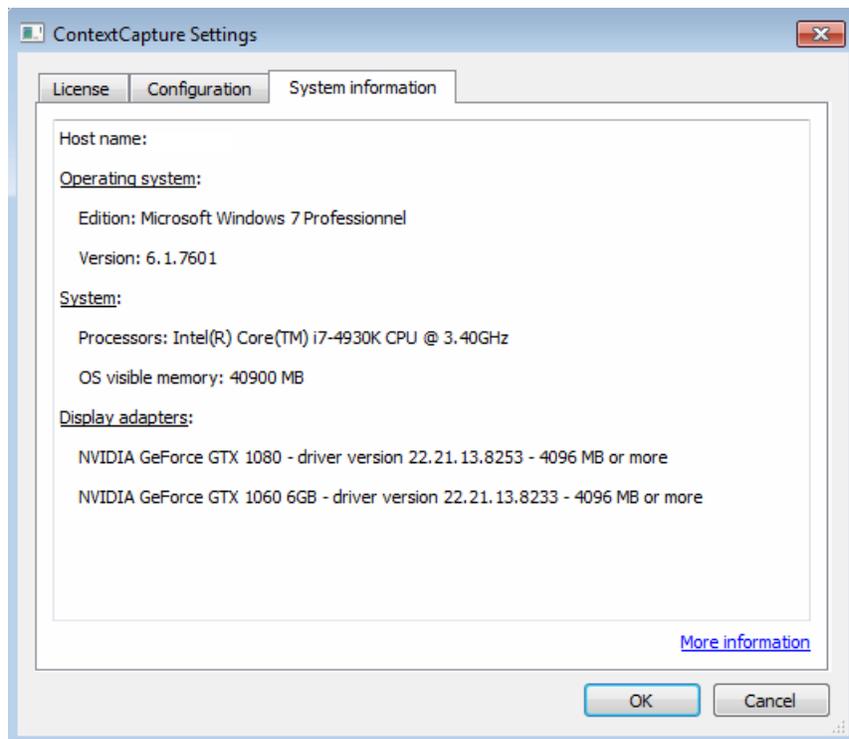


Figure 1: System information in ContextCapture Settings

## Licensing

ContextCapture licensing is based on Bentley CONNECT licensing.

CONNECT licensing is Bentley's improved licensing model that is being implemented for enhanced security and optimized value for an organization's Bentley Subscriptions. It will not only give organizations more options to monitor and manage their usage but also provide new, advanced licensing features that enhance digital workflows.

CONNECT Licensing integrates the new licensing system with Bentley's Identity Management System (IMS) and the Bentley CONNECT technology platform to allow near-real-time reporting of usage, improved notification and messaging to the user and increased administrative capabilities for organization administrators.

The highlight of CONNECT licensing is the ability to give end users near-real-time alerts, if continuing to start the product will likely generate a term license (also known as overage). If an overage situation is detected, the user will be given an alert and have the option to quit the application before a license is used or to acknowledge that a term license will be generated and proceed with opening the product.

However, this alerting is not a feature that will be enabled by default but, instead, will need to be enabled by an organization's license administrator. Those organization administrators can also grant or deny access to a user for a particular product and to configure other restrictions such as disabling offline usage which would be necessary if the organization is intent on limiting term license generation.

ContextCapture Users will have to sign in to CONNECTION Client with a valid IMS ID associated with their account to access Bentley products and features. By signing into CONNECTION Client users can also find their organization's projects, download software updates, receive relevant notifications, and track their usage.

# Welcome

## Licensing

Used to step through the product activation process. After a product is installed, you must obtain a license and then activate that license.

### Bentley Licensing Tool

Open *Bentley Licensing Tool* to manage your license (*Start menu > Programs > CONNECTION Client > Bentley Licensing Tool*).

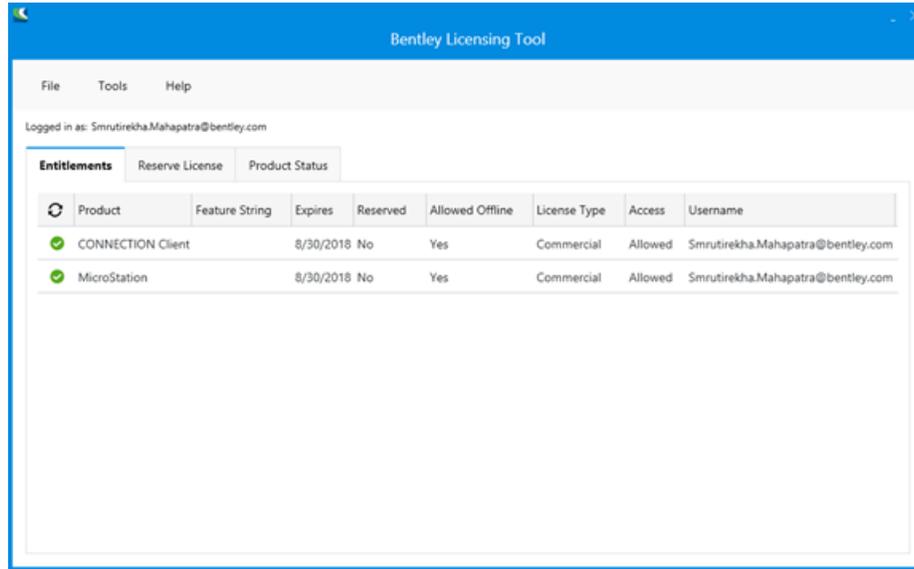


Figure 2: Bentley Licensing Tool

- Entitlements: Allows you to view the products you have entitlement to and related information like date of expiration of license, whether it is reserved or not, type of license and so on.
- Reserve License: Allows you to reserve a license if you want to use the product in offline mode for more than the seven days. You have to sign-in to CONNECTION Client to use the product for the first time. For any subsequent use you can use it in offline mode for a period not more than seven days after which you have to sign-in again or reserve a license.
- Product Status: Shows the list of products you are entitled to and information about their version, duration it is enabled for and so on.

### CONNECT License Client Activation Dialog

You can access this dialog from the Bentley Licensing Tool dialog: menu Tools > Activation Wizard.

Used to activate any products. You can pre-activate the products that you wish to use in this dialog, reserve a product of a specific period of time or import a policy file. You can also view which products you do or do not have access to, in this dialog.

Select the method of activation:

# Welcome

## Licensing

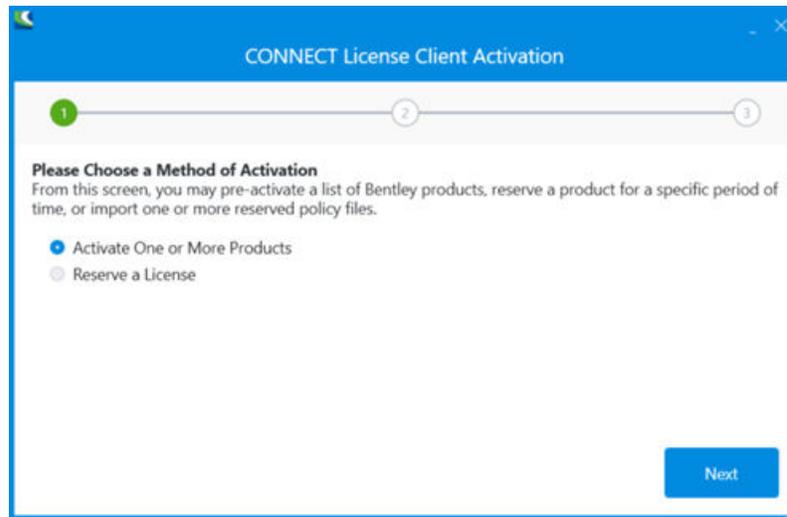


Figure 3: Selection of a method of license activation

- **Activate One or More Products:** Allows you to pre-activate products you wish to work on.
- **Reserve a License:** Allows you to reserve a license for a specific period of time.

Select products to activate:

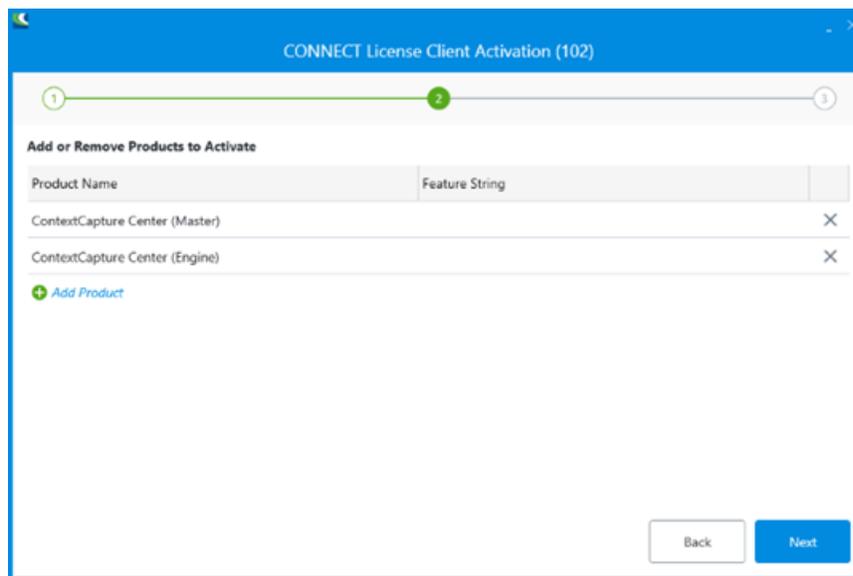


Figure 4: Selection of products to activate

Add or remove products to the list and click Next.

Check the Product activation summary:

# Welcome

## Useful concepts

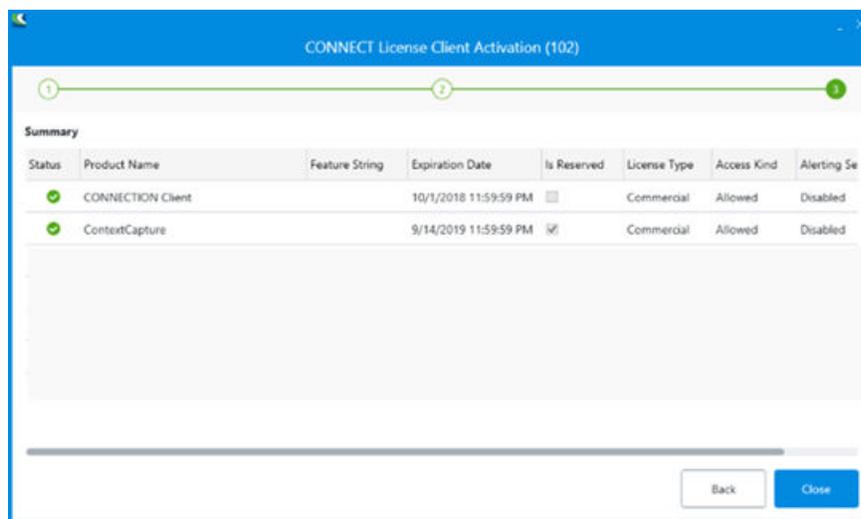


Figure 5: Product activation summary

Check the product activation list and click Close.

**Note:** If you are using an evaluation license of ContextCapture, your license will be valid for a 30-day period and watermarks will be applied to the texture of all produced 3D models.

Please read carefully the End User License Agreement in the ContextCapture installation directory.

## Useful concepts

An advanced use of ContextCapture requires to know a few concepts of photogrammetry and geodesy.

The interior orientation - or intrinsic parameters - of a camera refers to some internal properties of the camera: the size of the camera sensor, the focal length of the lens, the position of the principal point in the image plane, and the distortion of the lens.

We call photogroup a set of photographs with identical interior orientation. In the sequel, photogroup properties will refer to the interior orientation shared by all photos of a photogroup.

**⚠** In practice, interior orientation is unique to one physical camera with all its settings fixed. Even for two cameras of the same model with same settings, their respective photographs do not constitute a single photogroup.

The exterior orientation - or pose - of a camera refers to the 3D position of the optical center of the camera and the 3D rotation of the coordinate system of the sensor in the world coordinate system.

To perform 3D reconstruction from photographs, ContextCapture must know very accurately the photogroup properties of each input photogroup and the pose of each input photograph. If you ignore these properties, or if you do not know them with sufficient accuracy, ContextCapture can automatically estimate them through a process called aerotriangulation - or aerial triangulation - sometimes abbreviated to AT.

One important step of aerotriangulation is to determine pixels in two or more different photographs which correspond to the projections of a same physical point in the scene:

- If the 3D position of the physical point is not known *a priori*, the photo correspondences form a tie point. ContextCapture can automatically generate a large number of tie points.

# Welcome

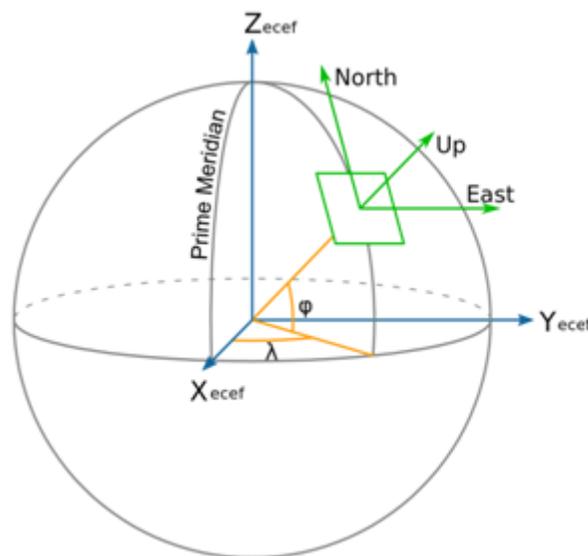
## Useful concepts

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- If the 3D position of the physical point is prescribed, the photo correspondences and the 3D position form a control point. When control points are present, the result of aerotriangulation can be accurately georeferenced. Whereas tie point generation is fully automated in ContextCapture, control points require some manual intervention to enter their 3D coordinates and their accurate projections in photographs.

When poses of photographs are georeferenced, ContextCapture uses the Earth Centered Earth Fixed (ECEF) spatial referential system. ECEF is a standard global Cartesian coordinate system. Please refer to <http://en.wikipedia.org/wiki/ECEF> for a complete definition.

Whereas ContextCapture uses ECEF for photo poses, it uses a local East North Up (ENU) spatial coordinate system for the 3D reconstruction process. ENU is a Cartesian coordinate system with a local origin, oriented along the WGS84 ellipsoid, with axes pointing to East (X), North (Y) and Up (Z) directions. ENU allows a more convenient manipulation of 3D models than ECEF, because its Z axis coincides with the up vector. However, please note that 3D models produced by ContextCapture can later be reprojected to any coordinate system.



In other circumstances, ContextCapture describes georeferenced positions using two geographic (longitude, latitude) or two projected (X, Y) coordinates, complemented with ellipsoidal height, which is the height above the reference ellipsoid (usually *WGS84*, but it may be a different ellipsoid, e.g. *GRS80*, for some spatial reference systems). Ellipsoid height differs from orthometric height, which is closer to the popular height above sea level. ContextCapture uses ellipsoidal height instead of orthometric height, because the former has a simple and unambiguous mathematical definition, whereas the latter is based on a geoid height grid subject to sampling and accuracy issues.

# 2

## Preparing the Imagery Dataset

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### Photo acquisition

#### Overlap

Each part of the subject should be photographed from at least three distinct - but not radically different - viewpoints. The overlap between consecutive photographs should typically exceed two thirds. Different viewpoints of the same part of the subject should be less than 15 degrees apart.

For simple subjects, you can achieve this by taking approximately 30-50 evenly spaced photographs all around the subject.

For aerial photography, a longitudinal overlap of 80% and lateral overlap of 50% or more are recommended. To achieve best results, acquire both vertical and oblique photographs, in order to simultaneously recover building facades, narrow streets and courtyards. ContextCapture is remarkably robust for unstructured acquisition. You may however prepare a flight plan for more systematic acquisitions.

#### Camera models

ContextCapture supports a wide range of cameras: mobile phone, compact digital, DSLR, fisheye, photogrammetric, and multi-camera systems. It can process still photographs or extracted video frames from digital video cameras. It does not support linear pushbroom cameras. It does not support rolling shutter cameras under fast motion.

Although ContextCapture does not require a minimum camera resolution, a higher resolution camera allows acquisition of a subject at a given precision with fewer photographs, and thus more quickly, than a lower resolution camera.

ContextCapture needs to know the width of your camera's sensor. If your camera model is not already listed in our database, you will be asked to enter this information. If you are unsure of your camera's specifications, you can consult your camera owner's manual or the *Digital Photography Review* website: <http://www.dpreview.com/products>.

#### Projected Pixel Size

In the sequel, the projected pixel size means the extension of the classical ground resolution to a more general, possibly not aerial, acquisition configuration.

# Preparing the Imagery Dataset

## Photo acquisition

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The resolution and precision of the generated 3D model is directly related to the projected pixel size on the subject. In order to achieve a desired projected pixel size, you must adopt a proper combination of focal length and distance to the subject, as defined by the formula below:

**projected pixel size × focal length × photo's largest dimension = sensor width × distance to the subject**

[m / pixel] [mm] [pixel] [mm] [m]

Uniform projected pixel size across the entire image is not required since ContextCapture will automatically propagate variations in projected pixel size to the resolution and precision of the generated 3D model. ContextCapture is unable, however, to join together photographs of radically different projected pixel sizes. If a wide range is required, photographs with intermediate values should be used to create a smooth transition.

## Focal Length

Using a fixed focal length throughout the acquisition process is recommended.

To achieve a non-uniform projected pixel size, vary the distance to the subject. If you cannot avoid several focal length settings, e.g., if the distance to the subject is constrained, shoot several series of photographs, each with a fixed focal length.

When using a zoom lens, make sure its position remains fixed over a series of photographs. You can use a piece of adhesive tape with a manual zoom lens to keep it in place.

Wide-angle or fish-eye lens can be used if the suited camera model type is specified, ContextCapture can automatically estimate extreme lens distortion.

Do not use digital zoom.

## Exposure

Select exposure settings that will avoid the motion blur, defocus, noise, and over or under-exposure that can seriously alter 3D reconstruction.

Manual exposure reduces the likelihood of color discrepancies in the texture map of the generated 3D model and is therefore recommended for those with the necessary photography skills and under fairly stable and uniform lighting conditions. Otherwise, automatic exposure may be used.

 Turning off optical or digital image stabilization is recommended.

## Lighting

Ambient, constant lighting is preferable to direct and/or time-varying lighting, since the latter increases the risk of overexposure and underexposure. For indoor acquisition, fixed lights are preferable to flash, and for outdoor acquisition, clouds (high-altitude cirrus clouds, no rain) are preferable to sun. If photos must be taken on a sunny day, take them around noon to minimize shadow areas.

Please note that correctly-exposed shadows do not affect the performance of ContextCapture, but will appear in the texture map of the generated 3D model.

## Photo Retouching

Before inputting photographs into ContextCapture, do not manipulate them, by resizing, cropping, rotating, denoising, sharpening or adjusting brightness, contrast, saturation or hue. Make sure to deactivate your camera's auto-rotate feature.

## Preparing the Imagery Dataset

### Input data file formats

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ContextCapture does not support stitched panoramic photographs. It requires the original photographs which were used to create the panorama.

## Photogroups

For optimal precision and performance, ContextCapture must group all photos taken by the same physical camera with identical focal length and dimensions (identical interior orientation) in one photogroup.

ContextCapture can automatically determine relevant photogroups if photos are organized in subdirectories according to the cameras used to shoot them: photos taken by different physical cameras (even if they are the same model) should be placed in separate subdirectories. Conversely, all photos taken by the same physical camera should be placed in the same subdirectory.

## Masks

A mask can be associated to a photo to cause specific parts of the image (e.g., moving obstacles, reflections) to be ignored in the workflow. A valid mask is a black and white TIFF image with the same dimensions as the photo. Pixels of the photo corresponding to black pixels of the mask will be ignored during aerotriangulation and reconstruction.

Masks are associated to input photographs through their file name:

- Associate a mask to one photo: for a photo named "*fileName.ext*", the mask file must be named "*fileName\_mask.tif*" and placed in the same directory as the corresponding photo.  
Example: for a photograph "*IMG0002564.jpg*", the corresponding mask should be "*IMG0002564\_mask.tif*"
- Associate a mask to an entire directory (requires photos of same dimensions): if present in a directory, the file "*mask.tif*" is used as a mask for all photos contained in this directory.

Masks can also be assigned to photos from the user interface once photos are loaded.

## Input data file formats

ContextCapture natively supports photographs in JPEG and TIFF formats. It can also read some of the more common RAW formats. ContextCapture uses Exif metadata if present.

Supported file formats:

- JPEG
- Tag Image File Format (TIFF)
- Panasonic RAW (RW2)
- Canon RAW (CRW, CR2)
- Nikon RAW (NEF)
- Sony RAW (ARW)
- Hasselblad (3FR)
- Adobe Digital Negative (DNG)
- JPEG 2000
- ECW
- PNG

ContextCapture can also import frames from video files in the following formats:

## Preparing the Imagery Dataset

### Positioning data

---

- Audio Video Interleave (AVI)
- MPEG-1/MPEG-2 (MPG)
- MPEG-4 (MP4)
- Windows Media Video (WMV)
- Quicktime (MOV)

Point cloud file formats

ContextCapture supports two common point cloud formats able to store scan positions:

- ASTM E57 file format (.e57)
- Cyclone point cloud export format (.ptx)

## Positioning data

One of ContextCapture e's breakthrough features is its ability to handle photographs that have no positioning data. In such a case, ContextCapture generates a 3D model with arbitrary position, rotation and scale, yet with a plausible up vector. However, ContextCapture also natively supports several types of positioning data including GPS tags, control points and can import potentially any other positioning data through position/rotation import or complete block import.

GPS tags, if present in Exif metadata or in an accompanying XMP file, are automatically extracted, and can be used to georeference the generated 3D model.

 Incomplete GPS tags are ignored (with latitude and longitude coordinates but without altitude).

GPS altitude reference *Sea level* and *WGS 84 ellipsoid* are supported.

Control points should be used whenever you need better-than-GPS georeferencing accuracy, or whenever you want to eliminate long-range geometric distortion caused by numerical error accumulation across the subject's extent. Georeferencing requires a minimum of three control points. Addressing long-range effects demands a higher number of well-distributed control points. The 3D position of control points must be obtained via traditional surveying methods. For each control point, you will have to manually point out a few (2 minimum, 3+ recommended) 2D measurements in photographs through the *Smart3DCapture Master* graphical user interface or a third-party tool.

See also [Control Points](#) (on page 59).

In addition to GPS tags and control points, ContextCapture can import potentially any other positioning data (e.g. inertial navigation system data) or third-party aerotriangulation results, through position/rotation text file, or through a dedicated XML or Excel format. Once imported, ContextCapture can use this data as is, or slightly adjust it, instead of computing it from scratch. This allows an even higher scalability and robustness.

See also [Import blocks](#) (on page 108).

# 3

## ContextCapture

### Principle

ContextCapture takes as input a set of digital photographs of a static subject, taken from different viewpoints.

Various additional input data may be provided: camera properties (focal length, sensor size, principal point, lens distortion), positions of photos (GPS), rotations of photos (INS), control points, ...

Without manual intervention and within a few minutes/hours of computation time depending on the size of the input data, ContextCapture outputs a high resolution textured triangular mesh.

The output 3D mesh constitutes an accurate visual and geometric approximation of the parts of the subject adequately covered by input photographs.

#### Suitable Subjects



# ContextCapture

## Principle

---

ContextCapture 's versatility allows to seamlessly reconstruct subjects of various scales, ranging from centimeters to kilometers, photographed from the ground or from the air. There is no limit in the precision of the resulting 3D model, other than the resolution of the input photographs.

ContextCapture performs best for geometrically-complex textured matte surfaces, including but not limited to buildings, terrain and vegetation.

Surfaces with no color variation (e.g. solid color walls/floors/ceilings), or with reflective, glossy, transparent or refractive materials (e.g. glass, metal, plastic, water, and to a lesser extent, skin) may cause holes, bumps or noise in the generated 3D model.

ContextCapture is intended for static subjects. Moving objects (people, vehicles, animals), when not dominant, can be handled at the price of occasional artifacts in the generated 3D model. Human and animal subjects should remain still during acquisition, or should be photographed with multiple synchronized cameras.

## Capturing close range - mid range subjects

This is a common bottleneck in many sectors: architecture, engineering & construction; manufacturing; media & entertainment; e-commerce; scientific analysis; cultural heritage. ContextCapture dramatically enhances productivity and opens new business opportunities in these different sectors, as illustrated by the example below.



*Figure 6: Autun Cathedral: Tympanum (courtesy of On-Situ)*

## Mapping large-scale urban or natural environments

ContextCapture goes beyond the photo-realistic flyovers, generated from tightly-controlled aerial imagery, offered by some popular online map services. It allows, in a completely automated manner, to turn various image sources (aircraft, helicopter, UAV, street-level) into a consistent and accurate real-3D model encompassing all scales, from large-scale relief to finer details of man-made constructions and objects and natural landmarks.

# ContextCapture

## Architecture



Figure 7: Paris (courtesy of InterAtlas)



Figure 8: Street 3D model (courtesy of V3D)

## Architecture

The two main ContextCapture modules are ContextCapture Master and ContextCapture Engine. They follow a master-worker pattern:

- [ContextCapture Master](#) (on page 30) is the master module of ContextCapture . Through a graphical user interface, it allows you to define input data and processing settings, to submit processing tasks, to monitor

## ContextCapture

### Architecture

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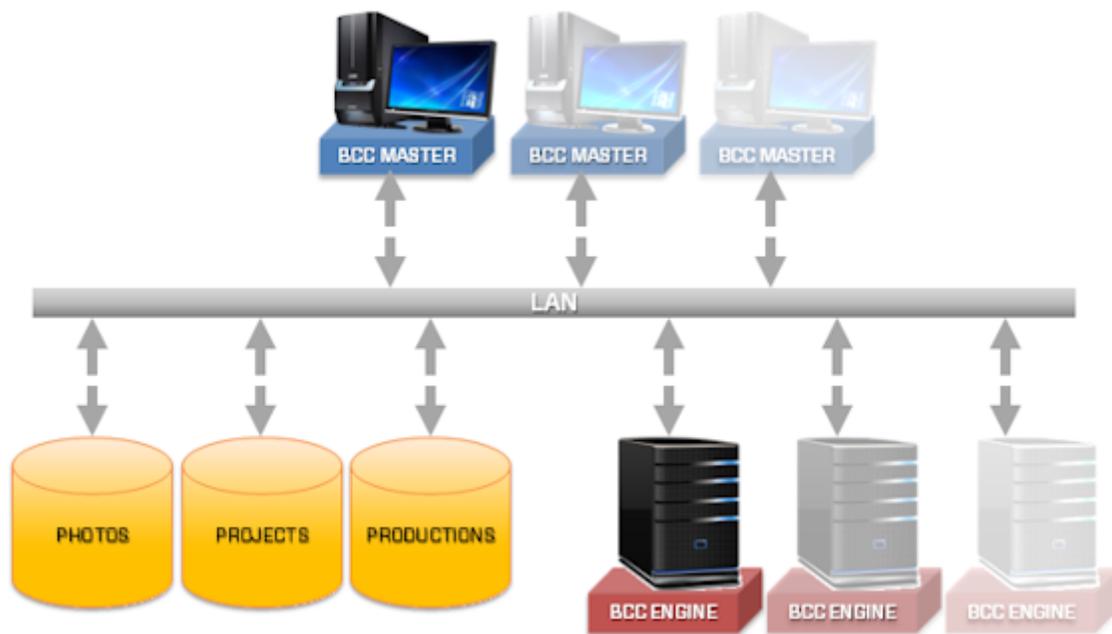
the progress of these tasks, to visualize their results, etc. The *Master* does not perform the processing tasks. Instead, it decomposes tasks into elementary jobs which it submits to a job queue.

- [ContextCapture Engine](#) (on page 198) is the worker module of ContextCapture . It runs on a computer in the background, without user interaction. When it is not busy, the *Engine* takes a pending job in the queue, depending on its priority and date of submission, and executes it. A job usually consists of processing aerotriangulation or 3D reconstruction, using various computationally intensive algorithms (keypoint extraction, automatic tie point matching, bundle adjustment, dense image matching, robust 3D reconstruction, seamless texture mapping, texture atlas packing, level-of-detail generation, ...).

For automation needs, ContextCapture Master interface can also be replaced by calls to a Python API. See also ContextCapture [ContextCapture](#) (on page 214).

Thanks to this master-worker pattern, ContextCapture supports grid computing. You can dramatically reduce processing time simply by running multiple ContextCapture engines on several computers, and associate them to a same job queue.

ContextCapture 's grid computing ability is based on the operating system's native file sharing mechanism. This allows ContextCapture to transparently handle a SAN, a NAS or a shared standard HDD. No specific grid computing architecture needs to be deployed.



- [ContextCapture Viewer](#) (on page 200) is ContextCapture 's free lightweight visualization module. It is optimized for ContextCapture 's native format, which handles level-of-detail, paging and streaming, thus allowing visualization of terabytes of 3D data, locally or online, with a smooth frame rate. You can use ContextCapture Viewer in conjunction with ContextCapture Master to control production quality all along the workflow. You can also use it to navigate final results.
- ContextCapture [Installation](#) (on page 10): to manage configuration of ContextCapture .
- License Management Tool: to manage licensing of ContextCapture .

## Workflow

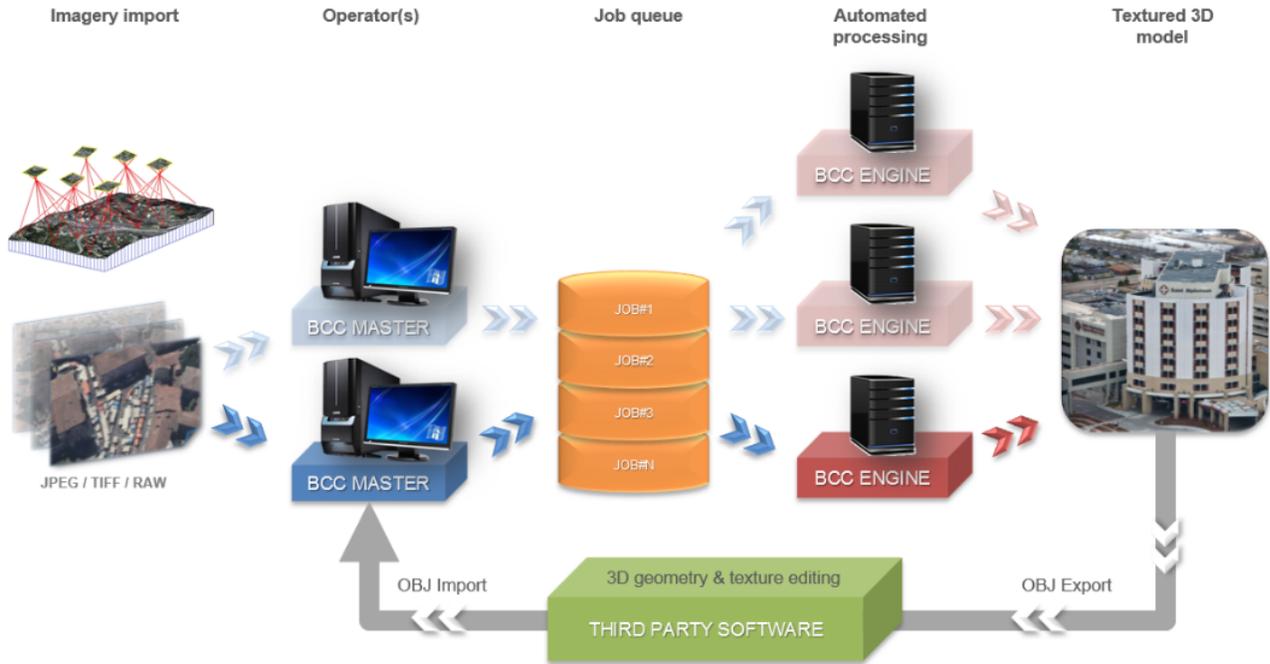


Figure 9: ContextCapture workflow

From the ContextCapture Master user interface, one operator (in some cases, there may be several operators working in parallel) define input data and processing settings, and submits the corresponding 3D reconstruction task to the job queue. One or several ContextCapture engines, when available, process the different elementary jobs, and store the results at the location defined by the operator in the ContextCapture Master user interface. From this interface, the operator can also directly monitor the status and progress of these jobs (Learn more about [Job Monitoring](#) (on page 215)). After the jobs are completed, the output 3D model is ready.

### Retouching

In most cases, the automatically generated 3D model can be used as is. But for some specific applications, an operator may prefer to fix the occasional geometric defects of the automatically generated 3D model in some third-party software, input this retouched 3D geometry in the ContextCapture Master user interface, and submit a novel 3D reconstruction task. In this case, the output 3D model is updated accordingly by automatically mapping texture to the retouched 3D geometry.

Learn more about [Retouching](#) (on page 187).

## System Requirements

ContextCapture natively runs under Microsoft Windows 8/10 64-bit.

It requires at least 8 GB of RAM and NVIDIA or AMD graphics card, or Intel-integrated graphics processor compatible with OpenGL 3.2 with at least 1 GB of dedicated memory.

# ContextCapture

## Performance

---

For specific Annotation jobs leveraging artificial intelligence, minimum GPU requirement are higher. A 4.0GB NVIDIA device with up-to-date drivers is the minimum we require.

Both desktop and rack-mounted computers are supported. Even multimedia or gaming laptops can be used, though with a significantly lower performance.

As of January 2020, the following configuration is recommended: a recent desktop computer running under Microsoft Windows 8/10 64-bit with 64 GB of RAM, an 8+core i9-CPU and an NVIDIA GeForce RTX 2080 Ti graphics card. Please contact the technical support team to design more powerful configurations (GeForce TITAN RTX, SSD Drives, etcetera.).

Input, working and output data should preferably be stored on fast storage devices (fast HDD, SSD, SAN). For file sharing, we recommend a >1-Gigabit Ethernet network.

## About Remote desktop connection

 ContextCapture Engine cannot work through a Remote Desktop Connection because hardware acceleration is disabled. However, you can use VNC or a remote administration software like TeamViewer.

## About Windows session

 Switching Windows user while ContextCapture Engine is running will cause running computations to fail because hardware acceleration is disabled when the user is not connected.

## About paths with non-ASCII characters

 ContextCapture does not support paths with non-ASCII characters. All specified input and output file paths must use only ASCII characters.

## Performance

ContextCapture exploits the power of general purpose computation on graphics processing units (GPGPU), yielding 50-times faster processing for some operations (image interpolation, rasterization, z-buffering). It also uses multi-core computing to speed up some CPU-intensive parts of the algorithms.

ContextCapture can process 10 to 20 gigapixels per day and per ContextCapture Engine on average, depending on the hardware configuration, for the production of a textured 3D mesh with Extra precision. For input point cloud datasets, ContextCapture can process about 250 million of points per day and per ContextCapture Engine.

You can dramatically reduce processing time with grid computing, simply by running multiple ContextCapture engines on several computers, and associate them to a same job queue.

Example: for vertical + 4-oblique aerial datasets with a ground resolution of 10-15 cm and a typical overlap, we have observed an average production rate of 30-50 km<sup>2</sup> per day on a cluster of 4 ContextCapture Engines.

Regarding memory use, one ContextCapture Engine with 8 GB of RAM can handle up to 1 gigapixel of input data and 10 million output triangles in one job.

## Software Editions

### ContextCapture edition

ContextCapture automatically reconstructs objects, buildings, man-made or natural landmarks, from imagery datasets of up to 300 gigapixels, or point clouds up to 3 billion points and a batch processing ability through a job queue. Most suited for, but not limited to, UAS /UAV/drone operators, this edition allows the production of high resolution 3D models as well as the generation of digital surface models (DSM) and true orthophoto.

### ContextCapture Center edition

ContextCapture Center is dedicated to larger-scale 3D surveying and mapping. It can handle an unlimited number of photographs without any limitation in size, and allows computations to be parallelized on a cluster of 3D reconstruction engines. It can import complex positioning data (example, inertial navigation system data), third-party aerotriangulation results and surface constraints. Consequently, it is adapted to massive 3D content production, like entire 3D cities from the air or from a mobile mapping system.

It can be customized to customer needs, for a seamless integration into the most demanding 3D production pipelines.

Compare ContextCapture editions

Features	ContextCapture	ContextCapture Center
Input imagery datasets	≤ 300 gigapixels	Unlimited
Input point cloud datasets	≤ 3 billion points	Unlimited
Automatic aerial triangulation / calibration	✓	✓
Automatic true 3D reconstruction (3D TIN)	✓	✓
Georeferencing	✓	✓
True orthophoto / DSM generation (GeoTIFF, JPG...)	✓	✓
Dense point cloud generation (LAS, POD, LAZ)	✓	✓
CAD interoperability (OBJ, FBX, Collada, STL, DGN...)	✓	✓

## ContextCapture

### Interoperability

Features	ContextCapture	ContextCapture Center
3D GIS interoperability (Agency9 CityPlanner, Eternix Blaze Terra, Google Earth, Skyline TerraBuilder, SpacEyes3D Builder, Supermap GIS, DIGINEXT VirtualGEO...)	✓	✓
Annotations (2D/3D objects, segmentation)	✓	✓
Free Viewer / web publishing	✓	✓
Unlimited tiling	✓	✓
Task queuing / background processing	✓	✓
SDK / Python scripting	✓	✓
Grid computing	≤ 2 computers	Unlimited
Reconstruction constraints (water surfaces...)	✓	✓
Quality control	✓	✓

Warning: Project file compatibility between ContextCapture editions is restricted. Reading of project files created from a higher edition is not permitted.

## Interoperability

ContextCapture is fully interoperable with 2D/3D GIS and CAD solutions through dedicated formats or via neutral formats.

ContextCapture can also export accurate camera properties, positions, orientations in various exchange formats.

See also [Export](#) (on page 114) and [Output formats](#) (on page 161).

## CAD/3D Software

With the standard Wavefront OBJ, Collada DAE, and FBX formats, 3D models generated by ContextCapture can be exported to a vast majority of CAD and 3D solutions including Bentley MicroStation, Autodesk 3ds Max, Autodesk AutoCAD, Rhinoceros 3D, Autodesk Maya, Autodesk Mudbox, Autodesk MeshMixer, MeshLab.

# ContextCapture

## 3D Visualization

---

ContextCapture can generate 3D meshes with multiple level of detail (LOD) to ease integration of large datasets into 3D solutions supporting this optimization.

For very large 3D models - such as cities - using the above formats can prove challenging, even with the LOD system. In this case, the 3MX format can be used to export the model to Bentley MicroStation.

## 2D/3D GIS software

Georeferenced 3D models can be produced in any coordinate system ( ContextCapture includes more than 4000 spatial reference systems and can be extended with user-defined ones) and in custom tiling systems compliant with GIS applications.

ContextCapture can produce 3D mesh models with level-of-detail and paging directly compatible with several leading 3D GIS software: [TerraExplorer](#) (Skyline), [SpacEyes3D Builder](#), [CityPlanner](#) (Agency9), [VirtualGeo](#) (DIGINEXT), [Blaze Terra](#) (Eternix), [Supermap GIS](#), [Google Earth](#), Cesium and more to come.

ContextCapture can generate true - orthophotos and DSM compatible will all standard GIS tools.

ContextCapture can export dense point clouds in ASPRS LASer (LAS) and Pointools POD format with color information on each point, that can be used in most point cloud analysis and classification software.

## 3D Visualization

ContextCapture includes ContextCapture Viewer, a free downloadable lightweight 3D visualization application working locally or online, under Windows.

### 3D visualization

ContextCapture Viewer is optimized for ContextCapture 's native 3MX, which handle level-of-detail, paging and streaming, thus allowing visualization of terabytes of 3D data with a smooth frame rate.

ContextCapture Viewer integrates 3D measurement tools (3D position in a configurable Spatial reference system, 3D distance and height difference, surface and volume computation) and tile selection tools.

You can use ContextCapture Viewer in conjunction with ContextCapture Master to control production quality all along the workflow. You can also use it to navigate final results and generate fly-through animations.

Free and downloadable on <http://www.bentley.com>, ContextCapture Viewer offers an instant solution for publishing 3D models in ContextCapture 3MX and S3C formats.

## Web publishing

ContextCapture users have several options for publishing their original 3D content on the Internet.

- Share images, scans, orientations and productions on ProjectWise ContextShare.
- Publish 3MX production with ContextCapture Web Viewer 1.0.
- Publish 3D Tiles to Cesium or to ContextCapture Web Viewer 2.0.
- Share S3C productions online.
- Publish to Sketchfab (OBJ format)

**Learn how to share and publish ContextCapture contents.**

# 4

## ContextCapture Master

---

The ContextCapture Master is the master module of ContextCapture . Through a graphical user interface, it allows you to:

- Import the data sets,
- Define the processing settings,
- Submit tasks,
- Monitor the progress of submitted tasks,
- Visualize results, etc.

The Master does not perform the processing tasks. Instead, it decomposes tasks into elementary jobs which it submits to a job queue.

ContextCapture Master 's main interface manages the different steps of the ContextCapture workflow through a project.

A project is organized along a tree structure. It contains items of different types, corresponding to each step of the workflow:

- [Project](#) (on page 31): A project manages all data relative to a scene processed by ContextCapture . It contains one or several blocks as sub-items.
- [Block](#) (on page 45): A block manages a set of input photos and their properties (photogroup properties: sensor size, focal length, principal point, lens distortion / pose: position, rotation), based on which one or several reconstructions can be created. These reconstructions are represented as sub-items of the block in the tree structure.
- [Reconstruction](#) (on page 134): A reconstruction manages a 3D reconstruction framework (spatial reference system, region-of-interest, tiling, retouching, processing settings), based on which one or several productions can be launched. These productions are represented as sub-items of the reconstruction in the tree structure.
- [Production](#) (on page 158): A production manages the generation of a 3D model, with error feedback, progress monitoring and notifications about updates of the underlying reconstruction (e.g. retouching).

A project can contain multiple items corresponding to a same step of the workflow, which allows complex versioning and/or variant management. This is very useful to experiment on a same scene with different input data and different processing settings.

The main interface is in the form of a project explorer from which you can browse all the items of a project.

# ContextCapture Master

## Project

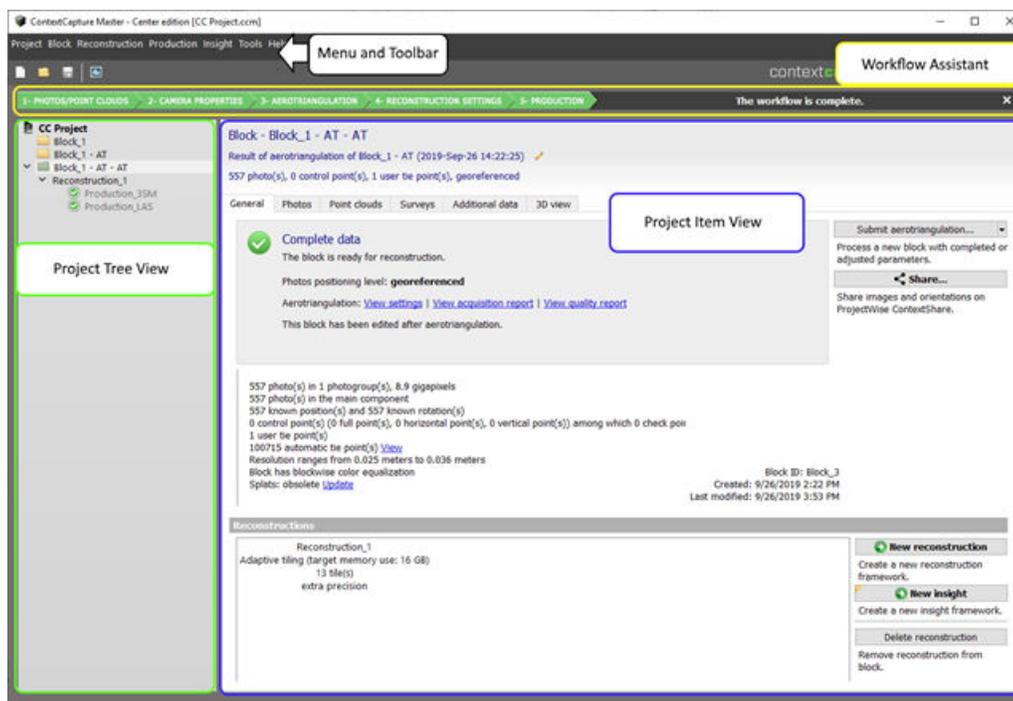


Figure 10: ContextCapture Master main interface

You can navigate in the project from the *project tree view*:

- The project tree view provides a direct access to any item in the project and provides an overview of the project (it includes a preview of the status of each project item).

The *central area (project item view)* manages data and actions relative to the active item. Its content depends on the type of the active item (*project, block, reconstruction or production*).

For some specific actions, the interface guides you through the workflow using dedicated modal dialogs or wizards.

ContextCapture Master submits jobs to ContextCapture Engine through a job queue. The [Job Queue Monitor](#) (on page 179) panel displays an overview of the job queue status and progress.

## Project

The Project item manages all data relative to a scene processed by ContextCapture .

# ContextCapture Master

## Project

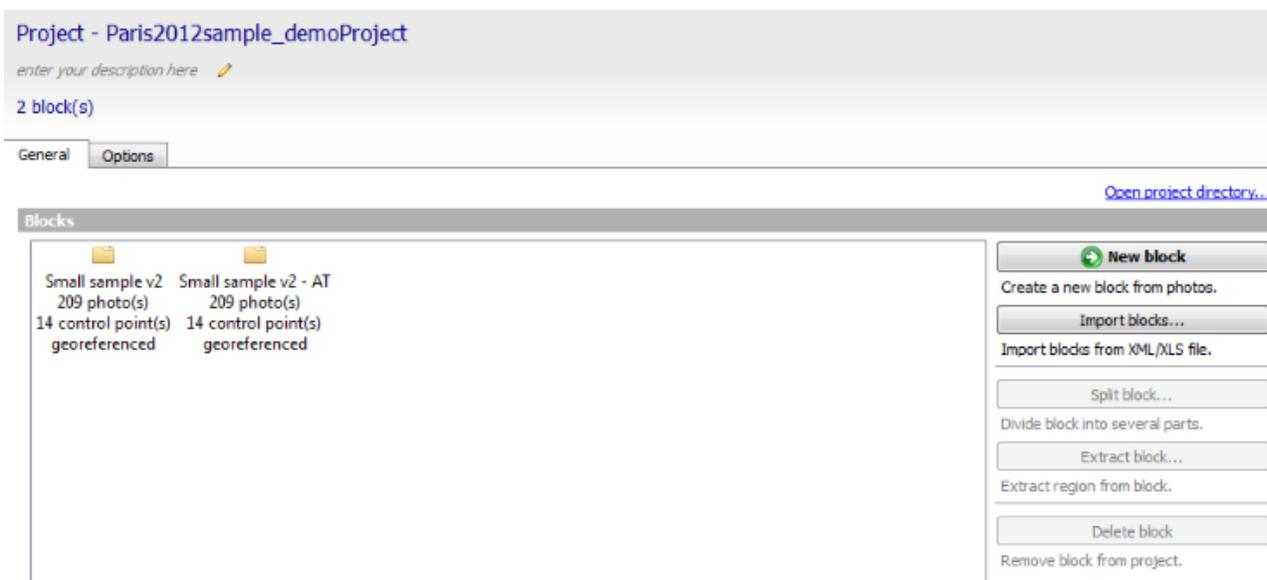


Figure 11: Project item interface

The project item is defined by a list of blocks and project options, managed from two tabs:

- The [General](#) (on page 32) tab manages the list of project blocks.
- The [Options](#) (on page 34) tab allows to set some options useful for computer clusters.

For the project, the [Reference manager](#) (on page 35) allows to check resources, and to repair or update links.

The [Basemap manager](#) (on page 38) is used to manage basemap layers accessible from project 3D views.

Project file compatibility between ContextCapture editions is restricted. Reading of project files created from a higher edition is not permitted. See [Software Editions](#) (on page 27).

## General

The project General tab displays project dashboard and manages the list of project blocks.

# ContextCapture Master

## Project



Figure 12: The project General tab

## Dashboard

The *General* tab may display contextual information about the project status.

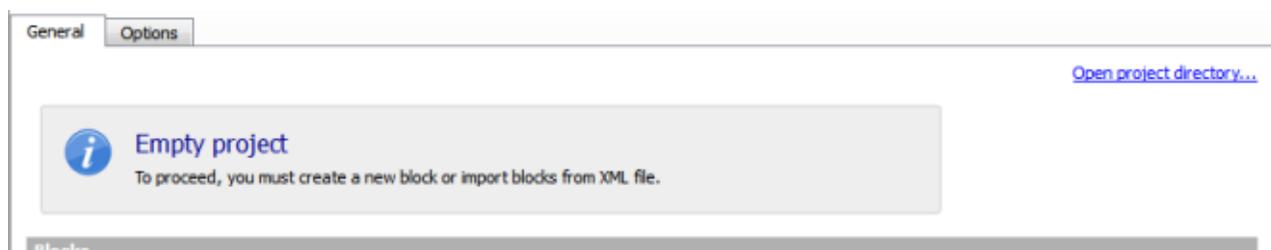


Figure 13: Example of project dashboard

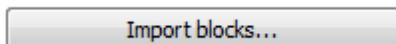
## Blocks

The *project* manages a list of [Block](#) (on page 45). You can create new blocks in different ways, or remove existing ones.



*Create a new block from photos.*

Creating a new block starts the ContextCapture workflow from scratch.



*Import blocks from XML or XLS file.*

Imports complete or partial blocks definitions from a *BlocksExchange* XML file or from MS Excel file.

See [Import blocks](#) (on page 108).



*Divide block into several parts (available only for a georeferenced aerial block).*

# ContextCapture Master

## Project

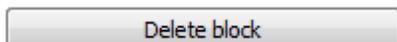
---

See [Split block](#) (on page 109).



*Extract region from block (available only for a georeferenced aerial block).*

See [Extract block](#) (on page 112).

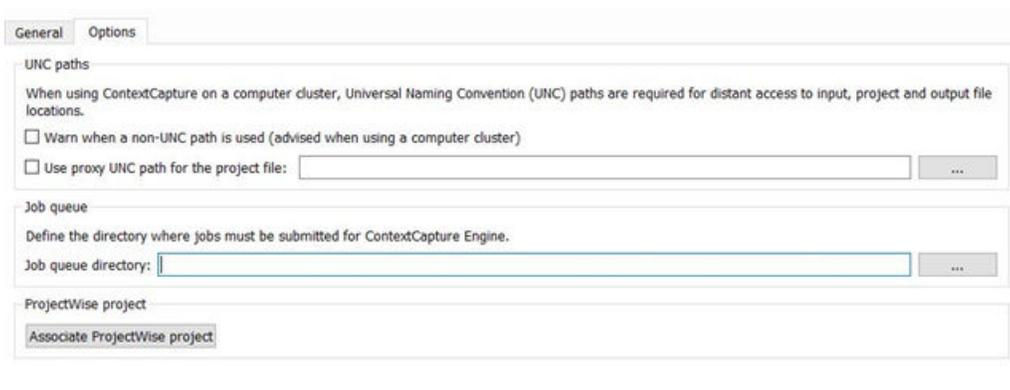


*Remove block from project.*

Remove all the block content including reconstructions and productions.

## Options

The project Options tab enables UNC paths definition and job queue management, helping cluster computing.



*Figure 14: The project Options tab*

### UNC paths

When using ContextCapture on a cluster, Universal Naming Convention (UNC) paths are required for distant access to input, project, and output files.

#### **Warn when a non-UNC path is used (advised when using a computer cluster)**

This option activates warnings in the user interface when a non-UNC path is used:

- for the project file location,
- for photo files,
- for the job queue directory,
- for the production output directory.

#### **Use proxy UNC path for the project file**

 Even if UNC paths are used everywhere in a project file, if the project is opened from a local location (for instance double-click on the CCM file in the local directory), non-UNC paths may be introduced in jobs and cause the computer cluster to fail.

To avoid this common cause of error, the proxy UNC path allows to define the UNC project file path used by ContextCapture, independently of the location the project is opened from.

# ContextCapture Master

## Project

---

### Job queue

Defines the directory where jobs must be submitted for processing by ContextCapture Engine.

This option allows to modify the job queue directory of a project. The job queue directory of a new project is initialized to the default value set by ContextCapture Settings (see [Installation](#) (on page 10) and [Configuration](#) (on page 11)).

### ProjectWise project

Your ContextCapture project can be associated to a ProjectWise project.

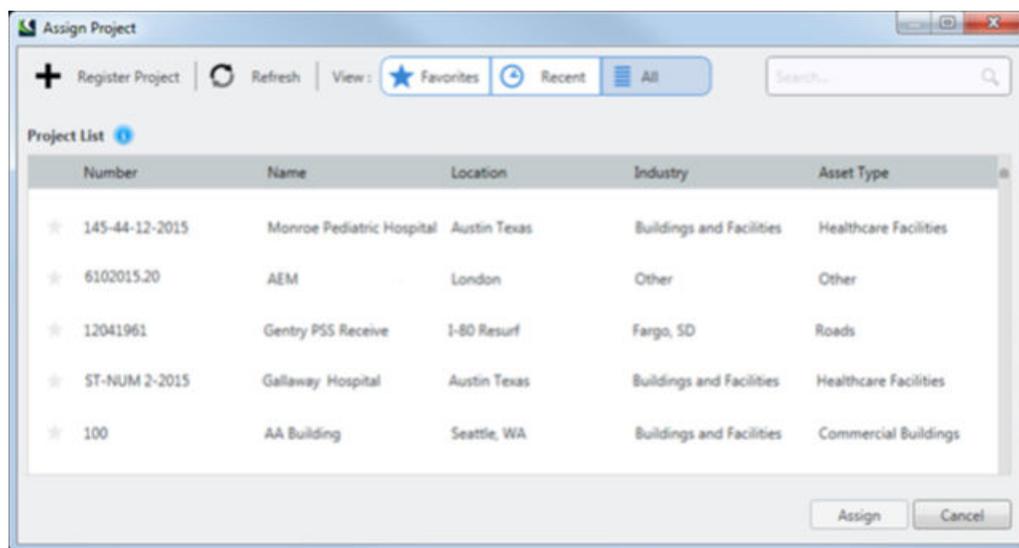


Figure 15: ProjectWise project chooser

Simply select a ProjectWise project to be associated with your work. See the ProjectWise Project Chooser documentation for more details on the various capabilities of this window. When associated, all use of the project in the current product is associated with the ProjectWise project.

### Reference manager

Check resources, repair or update links.

ContextCapture projects refer to several external resources: input photos and masks, as well as output directories. The reference manager interface allows you to check, repair or update corresponding links.

Some resources may be synchronized with the cloud. The reference manager dialog allows to check and control the synchronization.

# ContextCapture Master

## Project

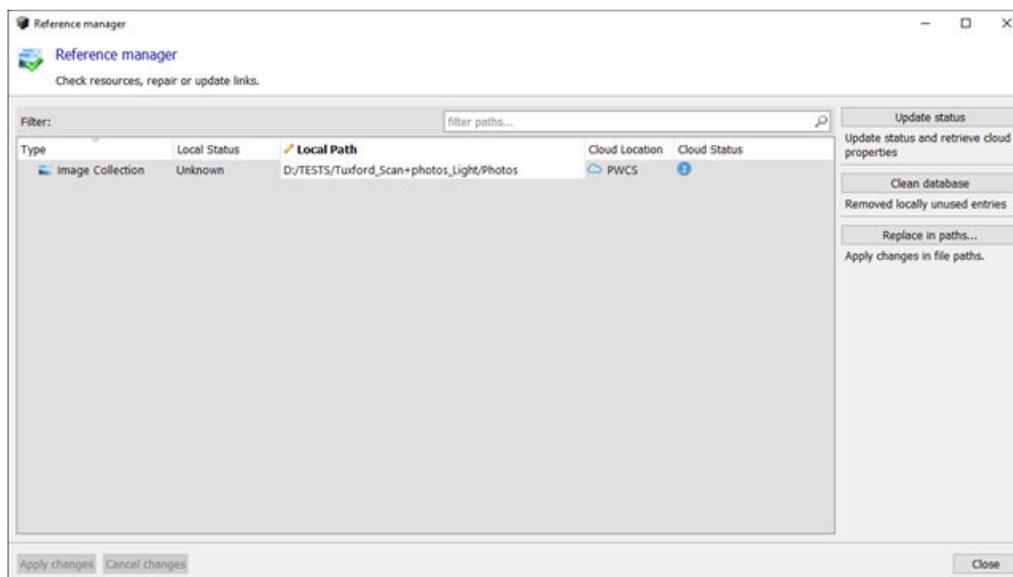


Figure 16: The reference manager interface

**Note:** If the project contains unloaded blocks, the reference manager will temporary load them in order to manage project references properly (see also [Load/unload blocks](#) (on page 117)).

Check resources status with *Update status*. Repair or update links with the *Replace in paths* tool, or editing resources paths directly.

Changes appear in bold characters in the resources table and are actually applied only when you click on *Apply changes*.

## Filter

*Filter resource table.*

Use the filter to quickly find resources from their location.

Filter supports simple wildcard matching (?, \*, etc.)

## Update Status

*Check access to resources and update the status column accordingly.*

## Replace in paths

*Make changes in file paths.*

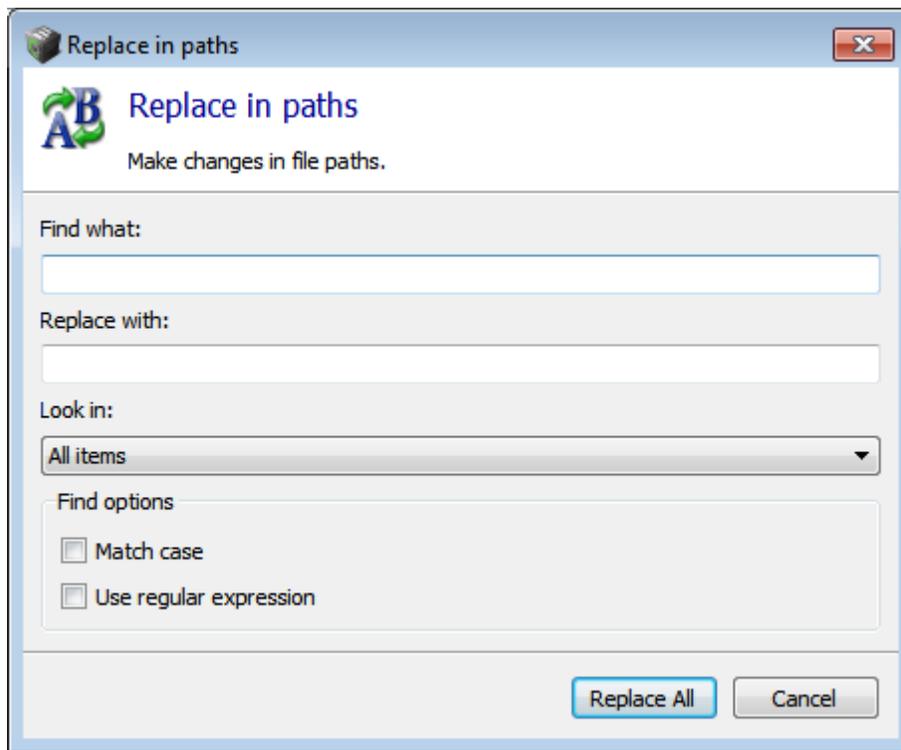


Figure 17: Replace in path dialog Enter the text to replace in Find what and the new text in Replace with.

Enter the text to replace in Find what and the new text in Replace with.

Look in: select *All items* to apply replacement to all the items of the current filter result, or *Selected item* to limit the replacement to the corresponding selection.

Find options: enable *Match case* or *Use regular expression* to perform advanced replacement operations.

## Management at resource level

Right click on a resource to display the resource context menu.

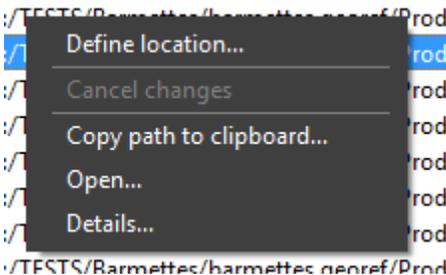


Figure 18: Resource context menu

## Apply changes

Apply pending changes (in bold).

Changes are applied only when you actually click on *Apply changes*.

 Depending on project complexity, applying path changes may take a significant time.

## Cancel changes

*Cancel all changes which are not applied yet (in bold), and restore initial values.*

## Basemap manager

The basemap manager is used to manage basemap layers accessible from project 3D views.

A basemap is a 3D representation of geospatial data used in project 3D views as context or as reference data. It is made of a Digital Terrain Model and a georeferenced image.

Your project must be georeferenced to be able to add basemaps.

ContextCapture can create basemaps from terrain and image data downloaded directly from Bentley's GeoCoordination Services or from local terrain and image files.

### **About Bentley GeoCoordination Services**

GeoCoordination Services is a geospatial data indexation service that allows you to easily find and download available data on your project area. It allows you to request the list of available data on the area, and get a selection of data for your project.

GeoCoordination Services proposes data on the following countries: USA, Canada. More countries will be covered in future versions.

GeoCoordination Services is a service reserved to Bentley CONNECT users. You must be logged in with Bentley CONNECT Edition to use it.

Notes: The GeoCoordination Services URL can be changed from ContextCapture Options. By default the following URL is used: "https://connect-contextservices.bentley.com/v2.3/Repositories/IndexECPlugin--Server/".

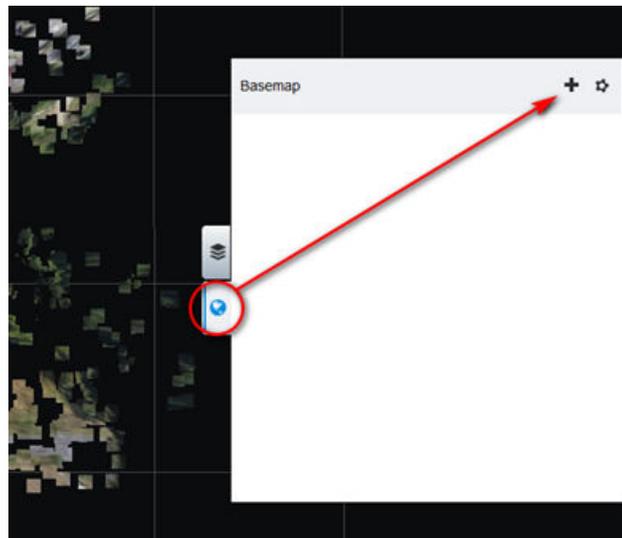
To open the basemap manager:

- from the project menu: select Basemap manager
- from the block 3D view, or from the reconstruction 3D view: click on the Layers button and select
- Basemap manager in the layers menu.

# ContextCapture Master

Project

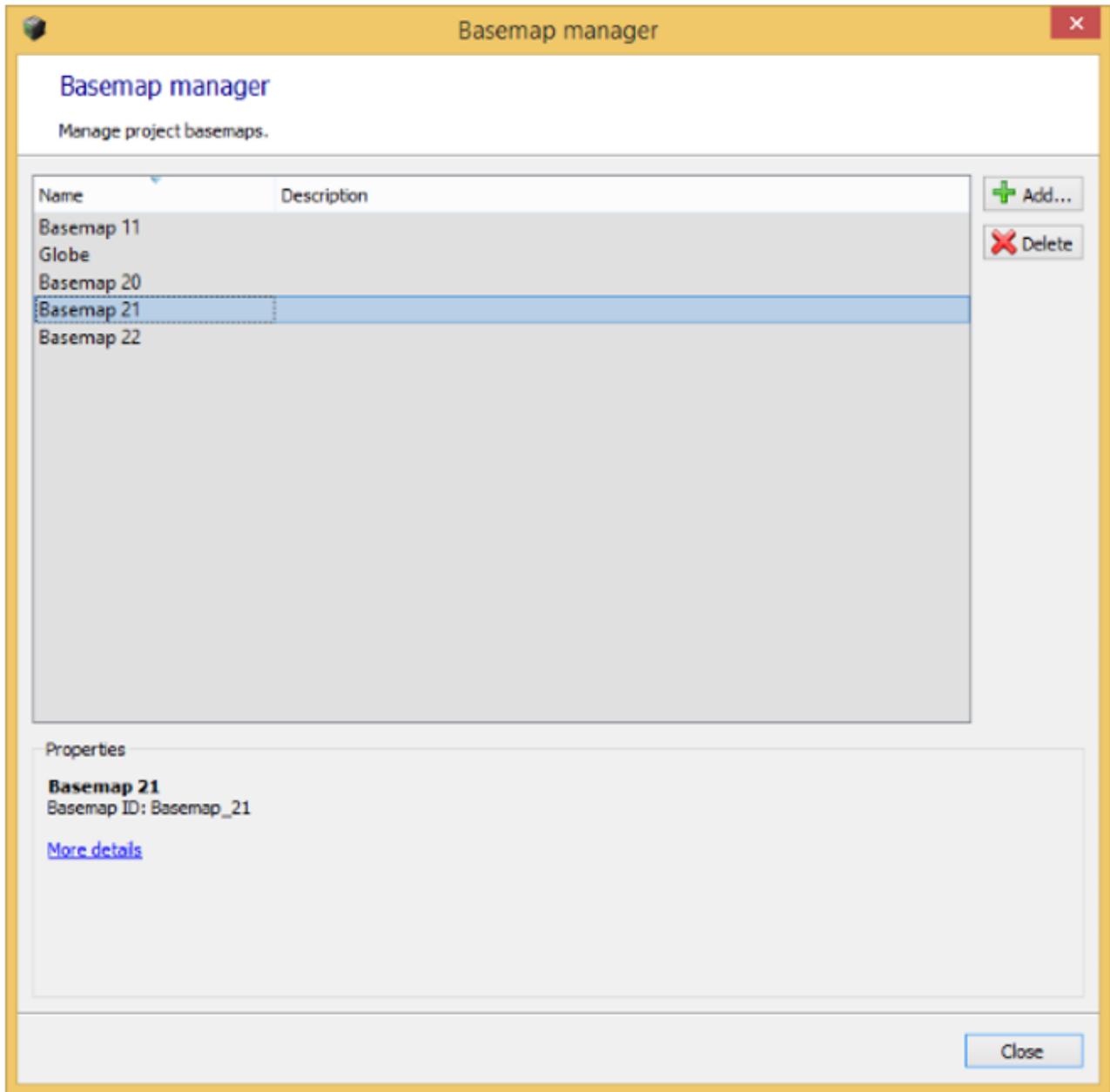
---



Opening the basemap manager from the block 3D view layers menu.

# ContextCapture Master

Project



The basemap manager window

To add a new basemap, click on Add in the Basemap manager window, or directly select Add basemap from the layers menu in the 3D views.

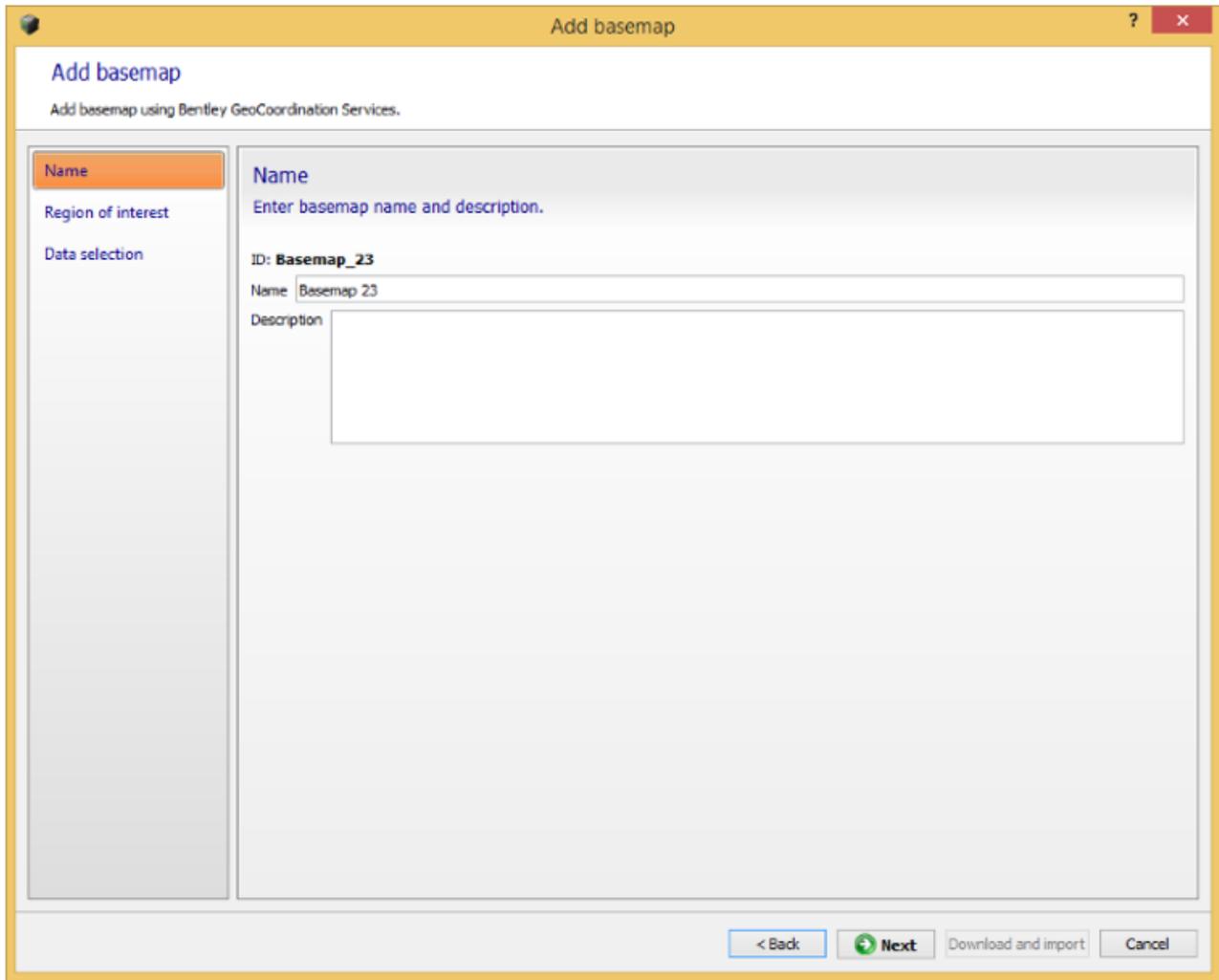
## Name

Basemap alias

Enter your preferred name for the basemap to be added.

# ContextCapture Master

Project



Adding basemap: the name page

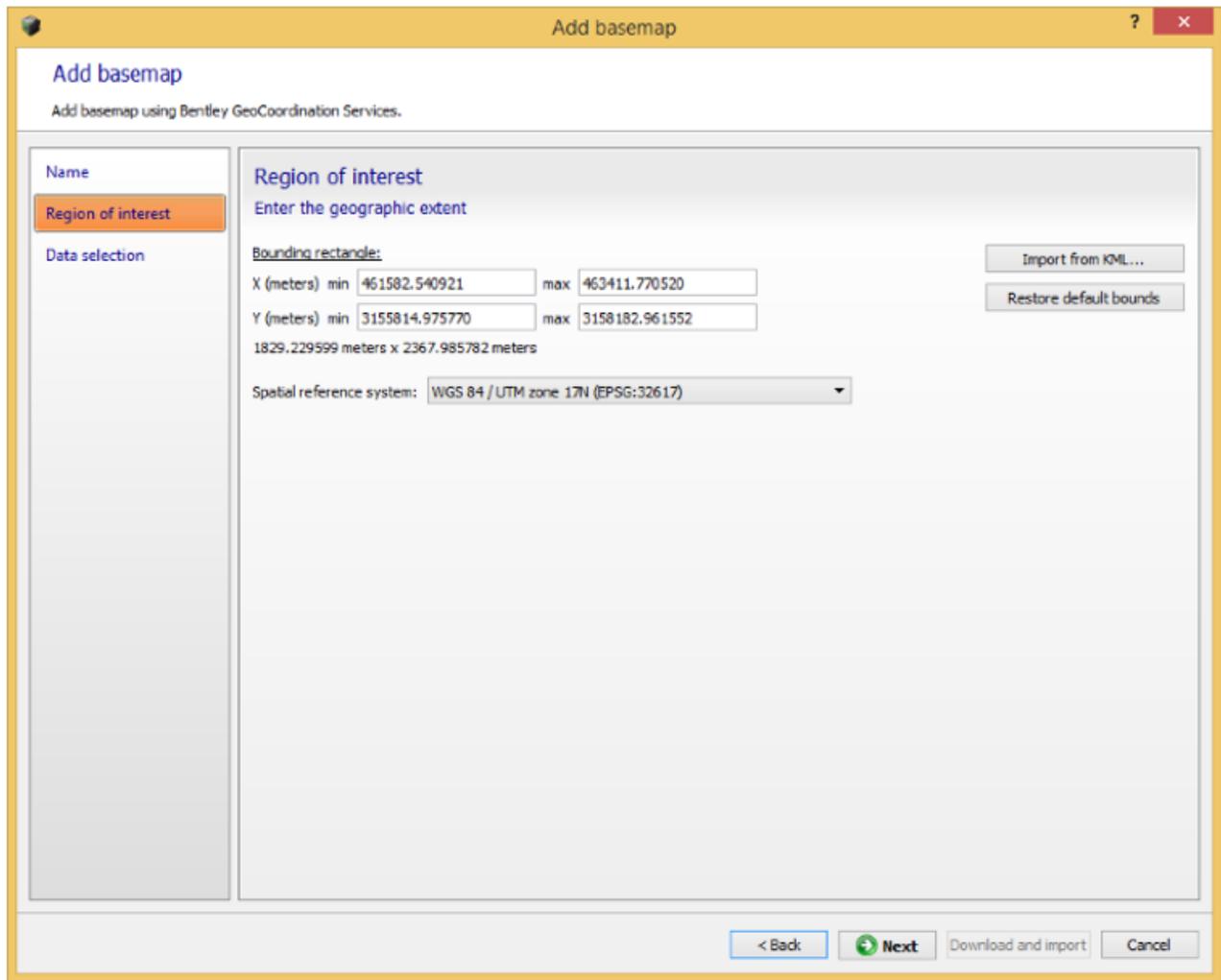
The name can also be changed later from the basemap manager dialog.

## Region of interest

Select the bounding rectangle of the basemap to create. The region of interest is used to request data from GeoCoordination Services, and to crop the selected input data to the area of interest.

# ContextCapture Master

Project



Adding basemap: the region of interest page

For blocks with existing photo positions, the initial region of interest is automatically set to contain all the positions with a margin. To change it you can edit bounds in the coordinate system you want, or import a KML polygon.

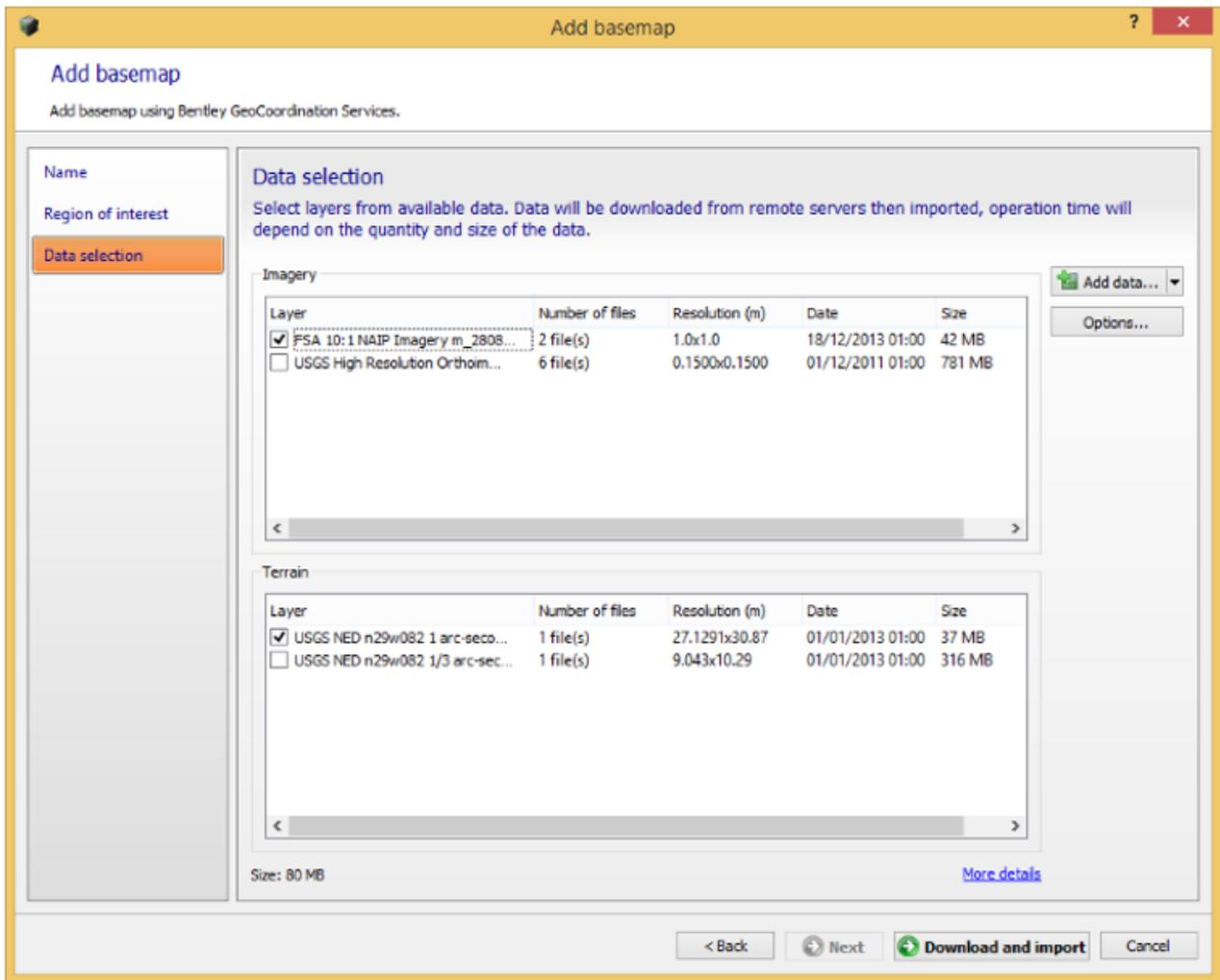
### Data selection

Select the list of data used to build the basemap.

The list of data contains spatial layers found by GeoCoordination Services on the given region of interest,

# ContextCapture Master

Project

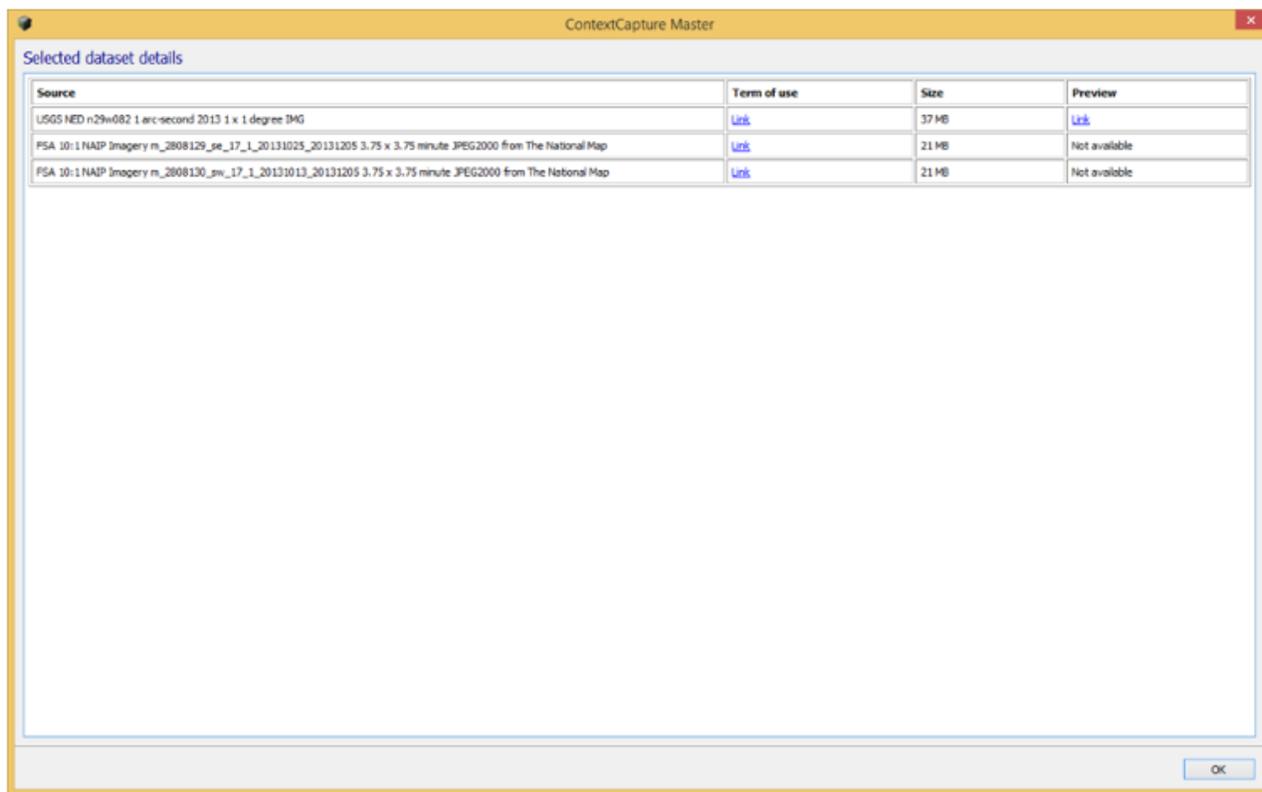


Adding basemap: the data selection page

Click on More details to get on overview of the selected data.

# ContextCapture Master

## Project



### Selected dataset details

You can also add local terrain or image files.

Supported local files are:

For terrain: raster DTM with known registered coordinate system in the following file format: GeoTiff, IMG, ASC.

For imagery: Image file with known registered coordinate system in the following file format: GeoTiff, JPEG2000, JPG, ECW.

Options:

Discard data outside the region of interest (default: activated): if disabled all the selected input data will be kept.

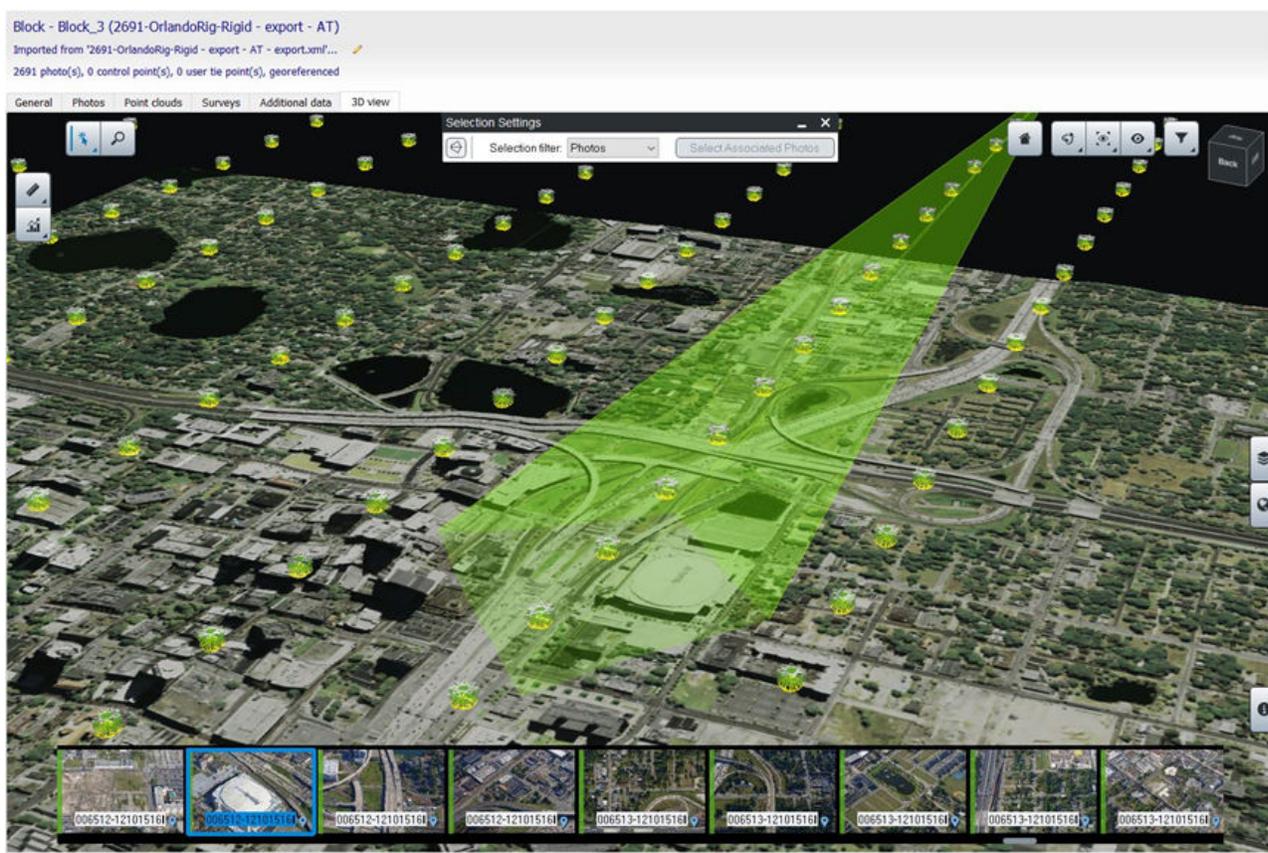
Height reference for input terrain file (default: Mean Sea Level): select the height reference for input terrain files. Most terrain files are based on Mean Sea Level, however we recommend to use terrain file based on the WGS84 ellipsoid to avoid precision loss when importing heights.

Select the list of layers to use to create the basemap, and click on Download and import to proceed.

ContextCapture starts by downloading data from remote servers if required, then process the 3D terrain model cache for rendering. Operation time will depend on the quantity and size of the data.

# ContextCapture Master

## Block



Example of a basemap created from GeoCoordination Services data

## Free Up Disk Space

This tool allows to cleanup project temporary files to save disk space.

## Block

A Block item manages a set of input data used for 3D reconstruction: photos and/or point clouds. The block item manages photos and their properties (photogroup properties: sensor size, focal length, principal point, lens distortion / pose: position, rotation), and optional point clouds.

Based on the block item, one or several reconstructions can be created.

A photo can be used for 3D reconstruction if it is complete. A photo is complete if it fulfills the following conditions:

- Its image file is in a supported file format (see [Input data file formats](#) (on page 19)) and is not corrupted,
- Its photogroup properties and pose (see [Useful concepts](#) (on page 15)):
  - Are known accurately,
  - Are consistent with the ones of other photos.

# ContextCapture Master

## Block

To achieve the two above conditions, photogram properties and photo poses must result from a joint optimization of the different photos of the block. The set of consistently optimized photos constitutes the main component of the block.

You can obtain a set of complete photos by two main methods:

- By adding photos to the block, with only a coarse guess of photogram properties, and then by using ContextCapture 's aerotriangulation to estimate complete and accurate photogram properties and photo poses.
- By importing photos with complete and accurate photogram properties and photo poses (e.g., from third-party aerotriangulation software) from an XML file (see [Import blocks](#) (on page 108)).

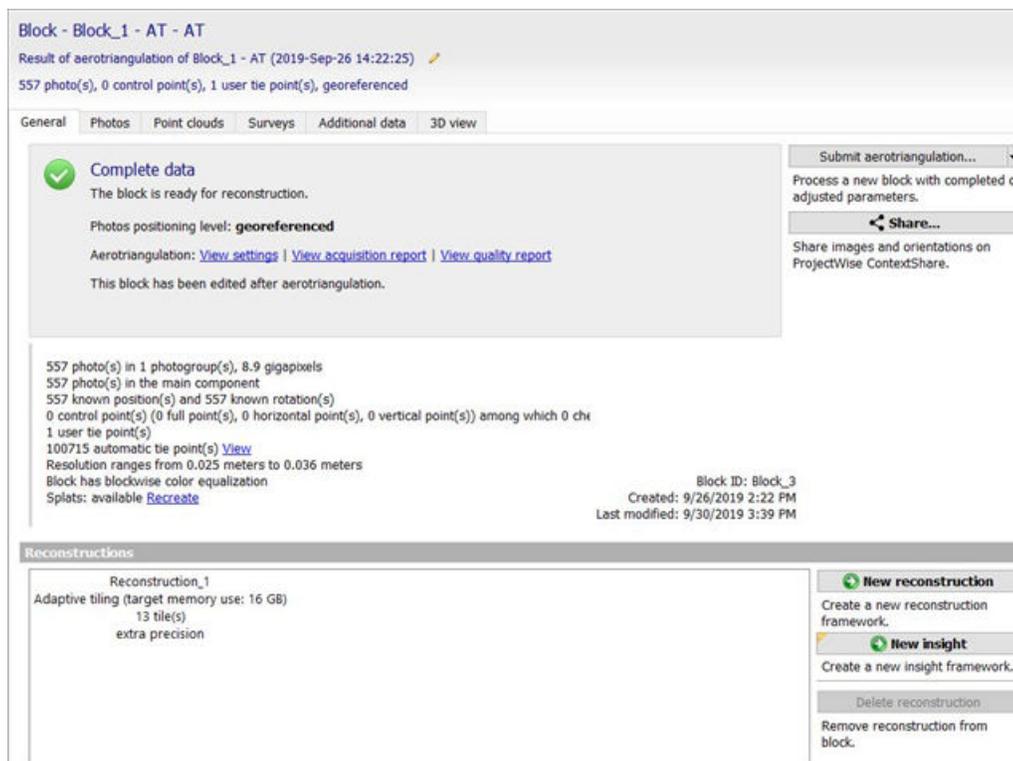


Figure 19: Block item interface

The block item is defined by the following properties:

- [Photos](#) (on page 48): the photos you imported or added, and their associated photogram properties and photo poses (computed by [Aerotriangulation](#) (on page 87), or imported).
- [Point clouds](#) (on page 54): imported from point cloud files.
- [Control Points](#) (on page 59): Control points or user tie points entered manually, or imported. Survey points are optional.
- [Tie points](#) (on page 64): automatically extracted by ContextCapture , or imported.
- [Surveys: Positioning Constraints](#) (on page 66): position/orientation/scale priors based on user tie points.
- [Additional data](#) (on page 86) additional knowledge on the acquisition used to help aerotriangulation.
- List of reconstructions based on the block.

The block [General](#) (on page 47) tab manages the block dashboard and block reconstructions.

# ContextCapture Master

## Block

For convenience, a block with some known 3D data (photo poses, control points, point clouds) can be displayed in 3D in the [Block 3D view](#) (on page 72) tab.

For a block, the following features are proposed:

- [Import blocks](#) (on page 108): import blocks from XML file.
- [Export](#) (on page 114): block can be exported to various file formats.
- [Split block](#) (on page 109): divide a large aerial block into several parts.
- [Extract block](#) (on page 112): extract region from block.
- [Load/unload blocks](#) (on page 117): load/unload blocks from the active project.
- [Merge blocks](#) (on page 118): merge a selection of blocks into one new block.
- [Share on ProjectWise ContextShare](#) (on page 117): share images and orientations on [Share on ProjectWise ContextShare](#) (on page 117).

**Note:** Once a reconstruction is created, properties are read-only. You can clone the block to get a new editable block initialized with the same properties.

## General

The block General tab manages the block dashboard and the list of reconstructions of the block.

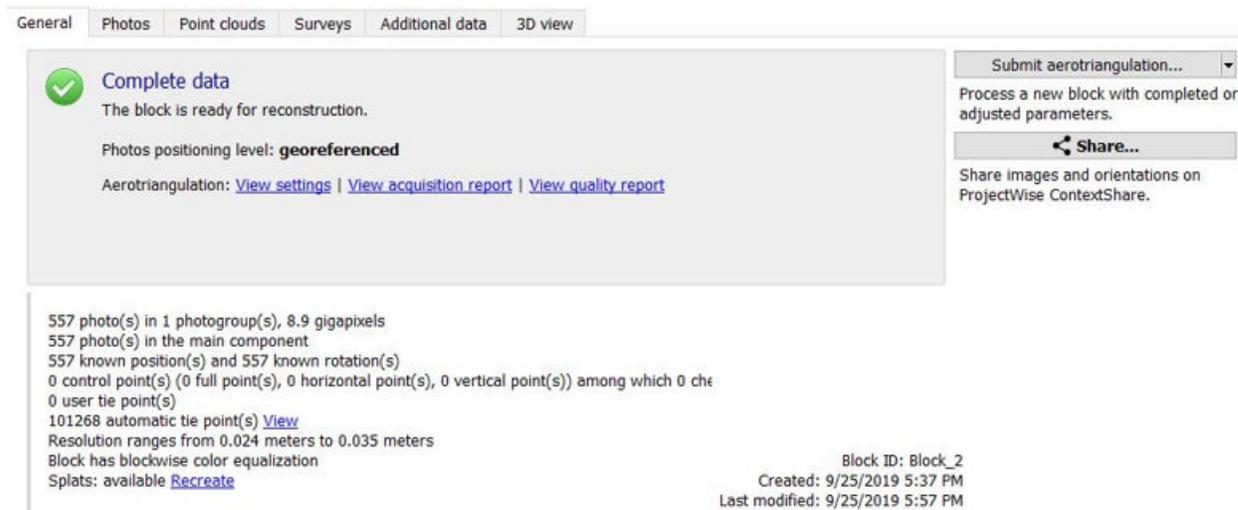


Figure 20: Block General tab

## Dashboard

The block *General* tab gives an overview of the block and possible actions in the workflow.

At any time, clicking on Submit [Aerotriangulation](#) (on page 87) will start processing a new block with complete or adjusted photogroup properties and/or photo poses processed locally with ContextCapture Engine or on the cloud (see Process on the cloud).

While the aerotriangulation of a new block is in progress, the block *General* tab is instead dedicated to monitoring.

# ContextCapture Master

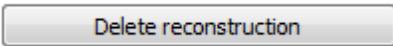
Block

## Reconstructions

Manages the list of reconstructions of the block.



Create a new reconstruction framework.



Remove the selected reconstruction from block.

See also [Reconstruction](#) (on page 134).

## Photos

The Photos tab is used to manage the set of photos and the associated properties.

**Note:** Once the block contains one or several reconstructions, the Photos tab is read-only.

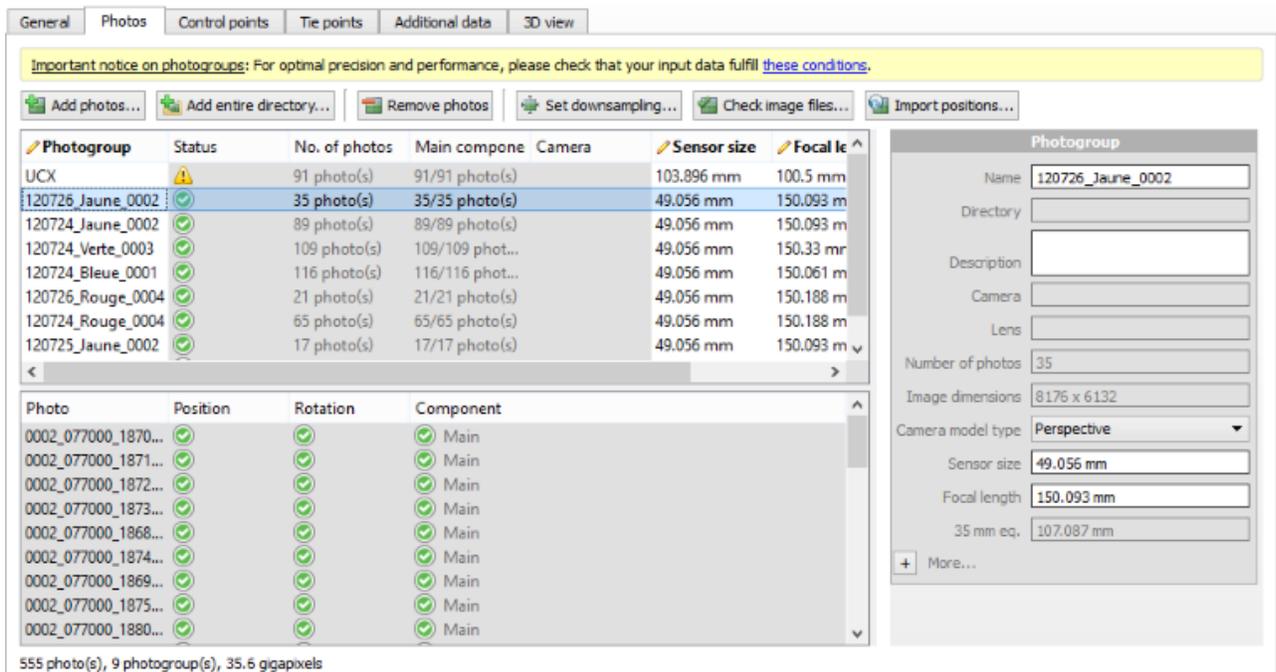


Figure 21: Block photos tab

## Adding Photos

For optimal performance, photographs must be divided into one or more *photogroups*. *Photogroups* are homogeneous sets of photographs, all taken with the same physical camera with identical interior orientation (image dimensions, sensor size, focal length,...). If the photos are organized in subdirectories according to the camera used to shoot them, ContextCapture can automatically determine relevant photogroups.

# ContextCapture Master

Block

---

See also [Input data file formats](#) (on page 19).

The size of the imagery dataset may be limited according to your edition. See [Software Editions](#) (on page 27).



*Add a selection of photo files.*

Use *Shift* or *Ctrl* to perform a multi-selection.



*Add all photos of a given directory (recursively or not).*

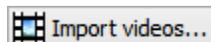
This command browses the chosen directory and adds all the photos found in this directory that are in a supported format.



*Download and add photos from image collections on ProjectWise ContextShare.*

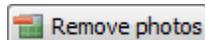
This command allows to select image collections from the cloud, download them, and add them to the block.

See also [Input data file formats](#) (on page 19).



*Extract frames from a video file and add them to the block.*

See [Import video frames](#) (on page 100).



*Remove photos or photogroups selected in the table.*

Use *Shift* or *Ctrl* to perform a multi-selection.

## Photogroups

### Photogroup properties

*Photogroup* properties define the interior orientation of the camera. Accurate estimates of photogroup properties are required for 3D reconstruction. These estimates can either:

- Be automatically estimated by ContextCapture by aerotriangulation, starting from some coarse estimates derived from EXIF metadata or using the ContextCapture camera database.
- Be imported (when importing a block, or from the camera database, or from an OPT file).
- Or entered manually.

### Multi-camera rig

Specifies if the photogroup defines a camera device that is part of a multi-camera rig. The supported options are None or Main. For a multi-camera rig setup to be valid, all the photogroups of the block must belong to it and all of them must fulfill the requirements of such setup.

### Camera model type

Two camera model types are supported:

# ContextCapture Master

Block

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- Perspective: perspective projection combined with a classical Brown's distortion model, suited for rectilinear lens or lens with low distortion.
- Fisheye: Suited for wide-angle or fish-eye lens with extreme lens distortion.

For more information about ContextCapture camera models, see [doc/ContextCapture camera model.pdf](#).

## Camera model band

Two camera model band are supported:

- Visible: standard RGB camera capturing visible colors.
- Thermal: Far Infra Red camera capturing temperature.

## Sensor size

ContextCapture may need to know the size of your camera's sensor. The needed *sensor size* is the sensor's largest dimension. If your camera model is not already listed in our database, you will be asked to enter this information. If you are unsure of your camera's specifications, you can consult the [Digital Photography Review](#) or contact Bentley Systems technical support.

**Note:** When a camera model is not listed in our database, the interface proposes to send a request to Bentley Systems. We will reply to your email in a timely manner, and we will include the missing camera model in the database of the next ContextCapture release.

**Note:** An undefined sensor size may be acceptable in some specific cases, e.g. if the 35mm-equivalent focal length is known from EXIF metadata.

## Focal length

For a newly created photogroup, ContextCapture can generally extract a coarse guess of the *focal length* in mm from EXIF metadata. Otherwise, you will be asked to enter this initial guess. Later, ContextCapture can automatically estimate the *focal length* more accurately by aerotriangulation.

We recommend to specify sensor size and/or focal length for each photogroup. If these properties are missing, ContextCapture will assume that the 35 mm equivalent focal length equals to 50 mm. If the correct focal length value differs significantly, the aerotriangulation may fail. In such cases it is required to specify initial camera properties manually.

For fisheye camera models, the focal length is ignored as soon as a fisheye focal matrix is defined (see below).

## Fisheye focal matrix

For the camera model type Fisheye, the fisheye focal matrix overrides the focal length property to model asymmetric fisheye focals.

Not used for perspective camera models.

## Principal point

For a newly created photogroup, ContextCapture considers that the principal point is by default at the center of the image. Later, ContextCapture can automatically estimate the principal point more accurately by aerotriangulation.

## Distortion

For a newly created photogroup, ContextCapture considers that there is by default no lens distortion. Later, ContextCapture can automatically estimate lens distortion more accurately by aerotriangulation.

Not used for fisheye camera models.

# ContextCapture Master

Block

## Fisheye distortion

Distortion model for the fisheye camera models.

Not used for perspective camera models.

## Aspect ratio/Skew

Properties used when pixels are not square.

- Skew: coefficient defining the angle between x and y pixel axes.
- Aspect ratio: different from 1 if the pixel are not square.

## Manipulating a photogroup

### Get from the camera database/add to the camera database

The camera model of photogroup can be added to or obtained from the camera database.

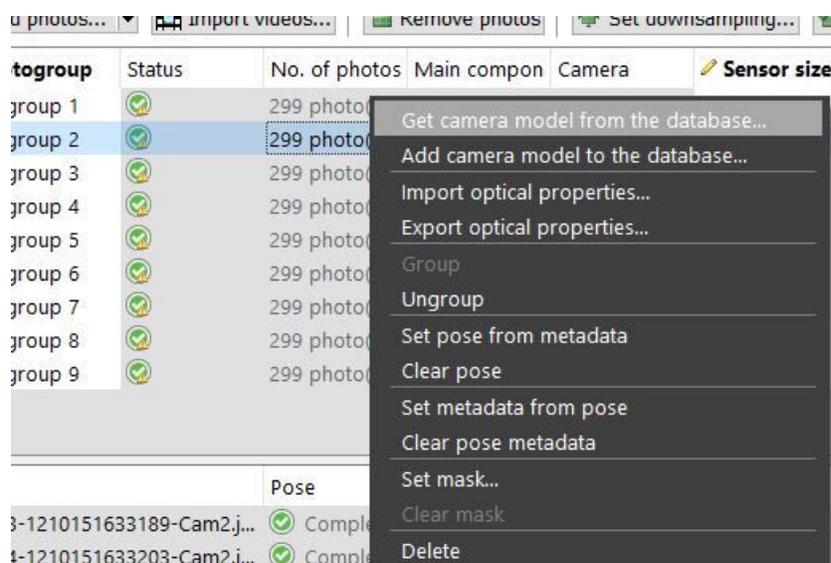


Figure 22: Accessing the camera database from a photogroup

See also [Camera database](#) (on page 129).

## Export/import optical properties

The properties of a photogroup (including sensor size, focal length, distortion, and principal point) can be exported and re-imported to/from an OPT file.

This feature can be used to re-use a camera calibration.

To import or export the optical properties, right click on a photogroup and choose *Export optical properties* or *Import optical properties* from the context menu.

## Ungroup/group photogroups

In some specific cases, the interior orientation of the camera must be estimated independently for each photo: for example, if photos were taken by a camera rig, or if the focal length varied slightly from one photo to the other during acquisition (zoom lens).

In such case, we recommend to prepare the dataset before adding photos in ContextCapture by placing each photo in a different subdirectory, to conform to [Photo acquisition](#) (on page 17). However, it is also possible to

add photos as is and use the *Ungroup* function: select all photogroups in the table, right click and choose *Ungroup* from the context menu to get one photogroup per photo.

See also [Photo acquisition](#) (on page 17).

## Photo properties

### Image

Each photo references an image file.

To edit references use the [Reference manager](#) (on page 35).

### Pose (position/rotation)

Photo *position* and *rotation* define the estimates of the photograph pose. Accurate estimates of photo poses are required for 3D reconstruction. These estimates can either:

- Be automatically computed from scratch or adjusted by ContextCapture by aerotriangulation,
- Be initialized from pose metadata (see below),
- Or entered manually.

### Pose metadata (position/rotation)

Metadata position and rotation define the known pose of the photograph. This metadata can be imported from GPS tags, third-party data, or during block import.

### Component

Another property of a photo is its component. Only the photos belonging to the main component of the block, i.e. photos resulting from a joint optimization, e.g. by aerotriangulation in ContextCapture or in third-party software, can be used for 3D reconstruction.

### Mask

A mask can be associated to a photo to cause specific parts of the image to be ignored in the workflow. A valid mask is a black and white TIFF image with the same dimensions as the photo. Pixels of the photo corresponding to black pixels of the mask will be ignored during aerotriangulation and reconstruction.

Masks are associated to input photographs through their file name:

- Associate a mask to one photo: for a photo named "*fileName.ext*", the mask file must be named "*fileName\_mask.tif*" and placed in the same directory as the corresponding photo.

Example: for a photograph "*IMG0002564.jpg*", the corresponding mask should be "*IMG0002564\_mask.tif*"

- Associate a mask to an entire directory (requires photos of same dimensions): if present in a directory, the file "*mask.tif*" is used as a mask for all photos contained in this directory.

Masks can also be assigned to photos from the user interface once photos are loaded: right click on a selection of photos to set or to clear the attached mask.

See also [Photo acquisition](#) (on page 17).

## Manipulating photos

### Use image GPS tags

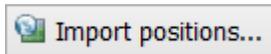
GPS tags, if present in Exif metadata, are automatically extracted, and can be used to georeference the generated 3D model.

 Incomplete GPS tags are ignored (with latitude and longitude coordinates but without altitude).

After adding photos with complete GPS tags, you are notified that GPS altitude has been interpreted using sea level as reference. Click on *Modify* to change the GPS altitude reference for the last added photos (Sea level or WGS 84 ellipsoid).

See also [Positioning data](#) (on page 20).

## Import image positions and rotations from a text file



*Import photo positions and rotations from a text file*

Use this option to set image positions and rotations from 3rd party data stored in text format. This import is an alternative to importing the entire block in XML or Excel format.

The *Import positions* button is enabled only if the block is not empty, since the aim of this tool is to pair each block photo with a line in the text file that indicates that photo's position.

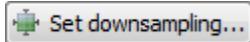
For more details, please refer to the dedicated chapter [Import photo positions](#) (on page 102).

## Set the displayed Spatial reference system

For georeferenced blocks, use this option to change the spatial reference system used to display position coordinates. This is a display option which does not affect block properties.

See also [Spatial reference system](#) (on page 192).

## Downsample photos



*Define a downsampling rate*

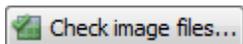
Downsampling photos reduces the quantity of information to process and affects the quality of results. It may be used to quickly produce a draft 3D model or to allow to process a large imagery dataset on a computer with a low hardware configuration and/or with a limited software edition.

Applying photo downsampling does not modify input photos.

Downsampling is defined by entering the percentage of original.

 Photo downsampling affects the quality of results.

## Check image files



*Check the integrity of image files*

This tool tests all block photos in order to identify missing or corrupted image files.

Two checking mode are proposed: *Check image file header only (faster)*, and *Load the entire image file (slower)*.

For convenience, if invalid image files are found, you are proposed to remove them from the block.

## Preview an image

Select a photo and click on *View* to visualize the photo with the integrated Image viewer.



Figure 23: Image viewer

### *About image quality*

Depending on image size, the image viewer may use a compressed cached copy of the image. Press the 'O' key to load the original image.

### *About image preview*

ContextCapture Master generates photo thumbnails in the background to accelerate preview display.

For very large images or when images are accessed from a remote location, preview creation may slow down the interface. In such case, it is advised to disable the preview.

## Point clouds

The Point clouds tab allows you to edit or display the set of input point clouds attached to a block.

**Note:** Once a reconstruction is created in a block, the Point clouds tab is read-only.

### **Importing point clouds**

Limitation: ContextCapture only supports point clouds with known scan source positions. Moreover, if scan source positions specified in the imported point cloud are incorrect, it will adversely affect the 3D reconstruction or even cause a completely incorrect 3D reconstruction.

The size of the imagery dataset and of the point cloud dataset may be limited according to your edition. See [Software Editions](#) (on page 27).

## Static scans

Point clouds can be imported from static scans in the following file formats:

- ASTM E57 file format (.e57).
- Cyclone point cloud export format (.ptx).
- LAS/LAZ file format (.las, .laz).
- POD Bentley point cloud format (.pod).

When importing a georeferenced point cloud file, please specify the spatial reference system when importing the file. Multiple files can be imported at once.

The scanner position must be known to allow 3D reconstruction with ContextCapture. When it's not accessible in the input file, the scanner position can be specified manually or detected automatically by ContextCapture by checking the corresponding options. Be careful in this case that the input file corresponds to one scan acquired from one unique position. To be able to automatically detect the scanner position, the scan must contain only scanner position that is clearly defined by an ellipse of high-density points on the ground. If you are importing multiple files at once, the autodetect feature is still available and will detect one position per file.

See also [Pointclouds Technical Specifications](#) (on page 270).

## Mobile scans

Point clouds can be imported from mobile scans in the following file formats:

- ASTM E57 file format (.e57) with trajectory files.
- LAS/LAZ file format (.las, .laz) with trajectory files.
- NavVis PLY format (.ply).

According to the format, the trajectories must be provided as separated text files (.txt or .csv) describing successive scanner positions associated with time. ContextCapture integrates a text file import wizard to extract trajectory data for various text formats.

3D points of the provided point clouds must also include time data to be attached properly to the trajectories.

See also [Pointclouds Technical Specifications](#) (on page 270).

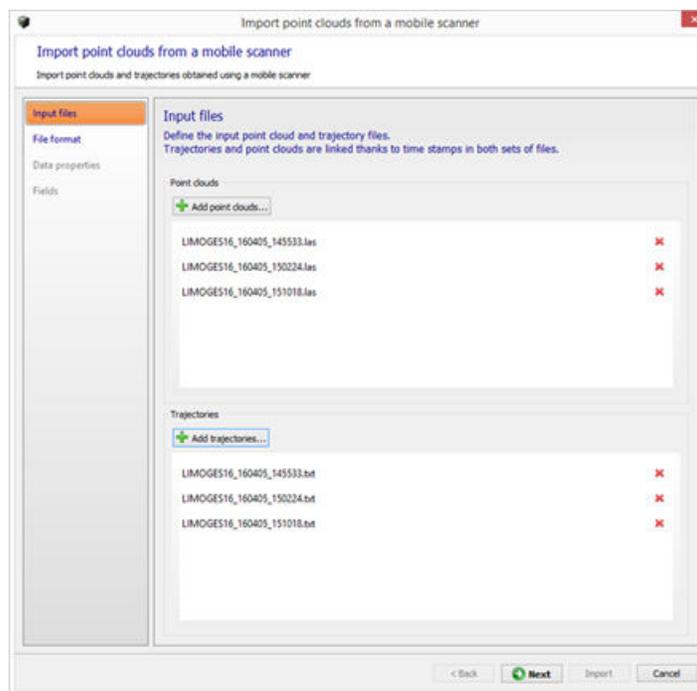


Figure 24: Import point cloud from mobile scans

## Input files

Define the input point clouds and trajectory files.

Trajectories and point clouds are linked through the time stamp in both sets of files.

## File format

Define how the trajectory files must be read.

You can adjust the import parameters, so that each column in the Data preview table contains meaningful information:

- Number of lines to ignore at the beginning of the file: defines the length of the file header, and ignores it during import.
- Delimiters: defines the column separators. Several characters can be specified.

The option Combine consecutive delimiters can be required, for instance when sequences of white spaces are used as delimiter.

- Decimal separator: dot (123.456) or comma (123,456).

## Data properties

When importing a georeferenced point cloud file from mobile scans, please specify the suited spatial reference system. Note that the point clouds and the trajectories must be in the same spatial reference system.

## Fields

Specify role of columns for the trajectory data.

You must associate each input column with its respective role.

X (easting), Y (northing), Z (height/altitude) and time are required.

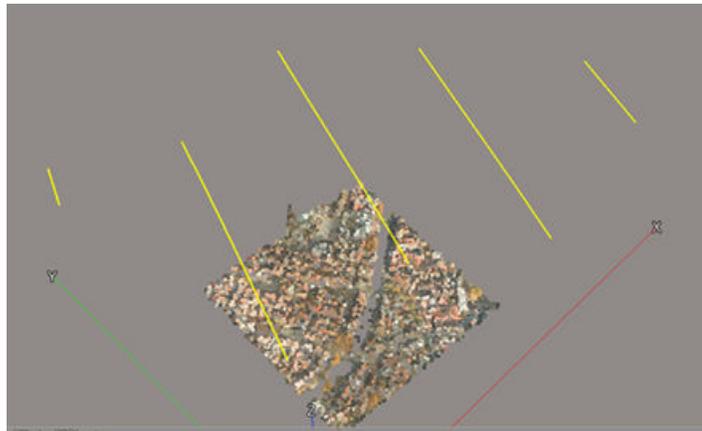


Figure 25: Example of point clouds imported from aerial lidar scans

### Import Scan Collections from ProjectWiseContextShare

Download and add point clouds from scan collections on ProjectWiseContextShare.

This command allows to select scan collections from the cloud, download them, and add them to the block.

### Managing point clouds

Point clouds are made of a set of scans corresponding to various scan sources with distinct positions or trajectories.

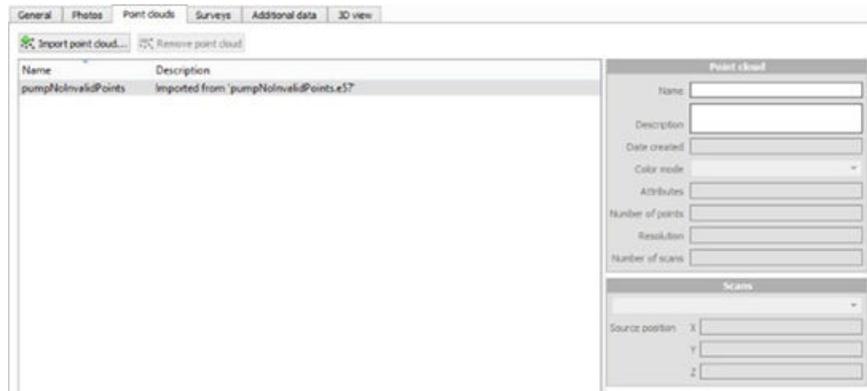
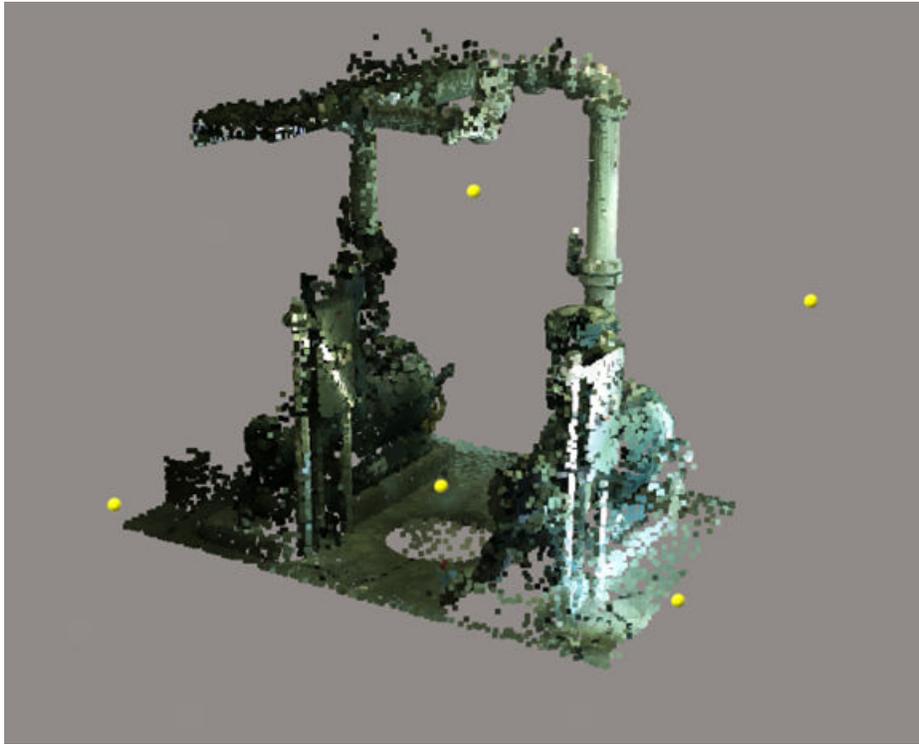


Figure 26: Point Clouds tab

Imported point clouds and scan positions are displayable in the block's 3D view tab.



*Figure 27: 3D display with scan sources of an imported point cloud file*

### Color mode

With this property you can select the color source for point cloud 3D display and texturing of the reconstructed 3D model according to the available attributes in the imported point cloud:

- Use color: use RGB color values.
- Use intensity: use intensity value and map it to gray scale.
- None: do not use point color.

### Surveys

The Surveys tab allows you to edit or display the survey data attached to a block: Survey points and positioning constraints.

**Note:** Once a reconstruction is created in a block, the Surveys tab is read-only.

# ContextCapture Master

## Block

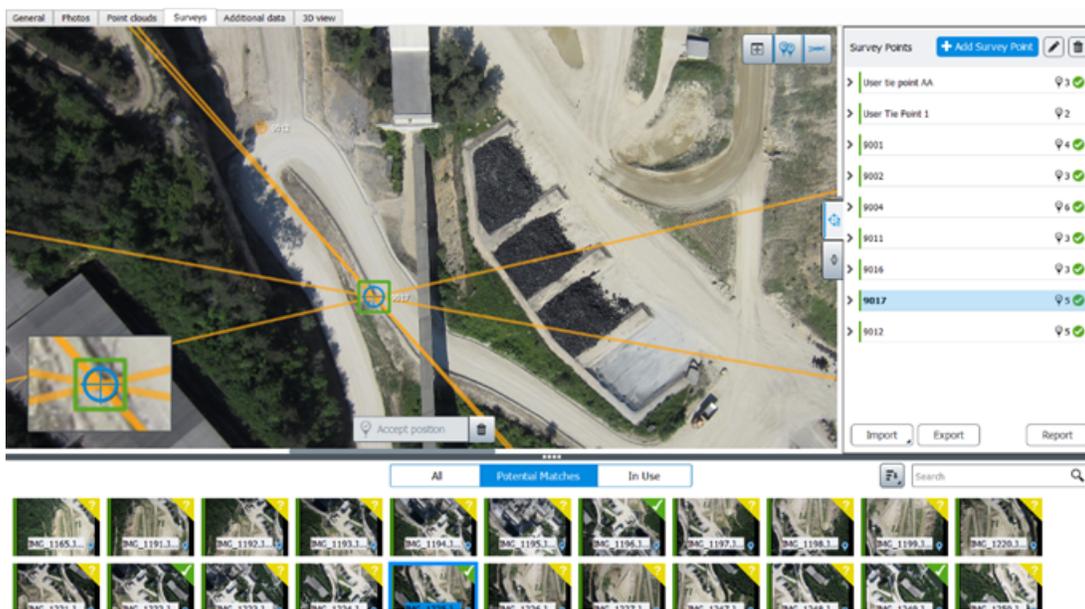


Figure 28: The Survey tab

Survey points are optional positioning data used during the aerotriangulation of the block.

Two types of survey points can be added:

- Control points - allow to enter known 3D coordinates of one point located on photos and are used to register the 3D scene.
- Tie points - allow to identify one point on photos and are used to create positioning/scaling constraint, or to stitch photos.

Survey points can also be used after the aerotriangulation to identify positions on photos and to perform Quality control (on page 141).

**Positioning constraints** are position/orientation/scale priors based on user tie points. They are used during the aerotriangulation of the block.

Surveys data can be optionally extracted from photos in an automatic way using targets. (See Aerotriangulation).

## Control Points

The Surveys tab allows you to edit or display the survey data attached to a block: Survey points and positioning constraints.

Control points are registered in 2D-images and correspond to a same physical point with known 3D-coordinate.

**Note:** Once a reconstruction is created in a block, the Control points tab is read-only.

Control points can be added manually or can be imported from a columned file. See also [Importing control points](#) (on page 61).

### Usage

Adding control points to a block enables accurate geo-referencing and avoids long-range metric distortion.

# ContextCapture Master

Block

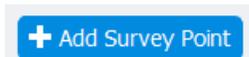
---

A set of control points can be used by aerotriangulation if it consists of 3 or more control points, each of them with 2 or more image measurements.

See also Aerotriangulation.

Adding a control point

1. Click on Add Survey Point.



2. Define Name.

A screenshot of the "Survey Point" dialog box. It has a title bar with "Survey Point" and a close button. The "Name" field contains "Control Point 1". The "Type" dropdown is set to "Control Point". To the right of the "Type" dropdown is a text box with the instruction: "Enter known 3D coordinates of one point located on photos. Used to register the 3D scene." Below this is a "Coordinate:" label and a dropdown menu set to "WGS 84". There are three input fields: "Longitude:", "Latitude:", and "Height:". At the bottom left, there is a red warning triangle icon and the text "Please enter 3D coordinates.". At the bottom right, there are "Create" and "Cancel" buttons.

In the Survey Point dialog, select Type "Control Point".

3. Enter 3D Coordinates

Select the input coordinate system in the combo-box, and the known 3D coordinates.

"Local coordinate system" system can be used to enter non-georeferenced control points with arbitrary units or with known units.

4. Click on Create

The new Control point appears in the list.

5. You can set additional control point options (category, accuracy, check point, etc.) from the item properties (page 62).

6. Place the survey point on photos.

Select a photo displaying the survey point, define its position in the photo with the yellow marker and click Accept position (alternatively, use Shift+Click to set directly the position on the photo).

# ContextCapture Master

## Block

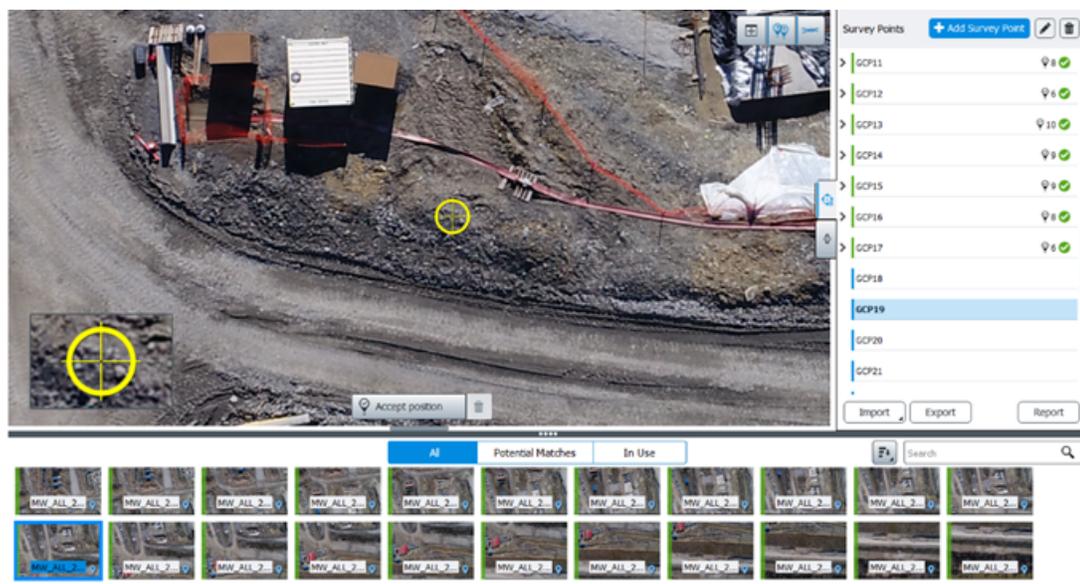


Figure 29: Defining positions on photos

Repeat the sequence of operations above to set the position in several photos.

### Importing control points

There are two ways to import control points:

- With the block import: control points can be part of the block definition. See also [Import blocks](#) (on page 108)
- With a control points text file imported from the Surveys tab (Import button).

Supported formats are TXT/CSV and ContextCapture Surveys (XML).

A basic example of supported control points files is a simple TXT file listing control points 3D positions with XYZ coordinates separated by a space.

*Control points text file sample:*

```
GCP_A 315796.627695945 4869916.09237971 627.8  
GCP_B 315332.029686681 4870703.80261219 738.9  
GCP_C 315483.66078491 4870210.48269584 833.2  
GCP_D 315399.200463097 4871212.13895964 906.5
```

Thanks to the import wizard, you can import a custom text format with delimiter-separated-values, including advanced property like accuracy.

When importing control points, please ensure you have selected the right spatial reference system (SRS) (See [Spatial reference system](#) (on page 192)).

# ContextCapture Master

Block

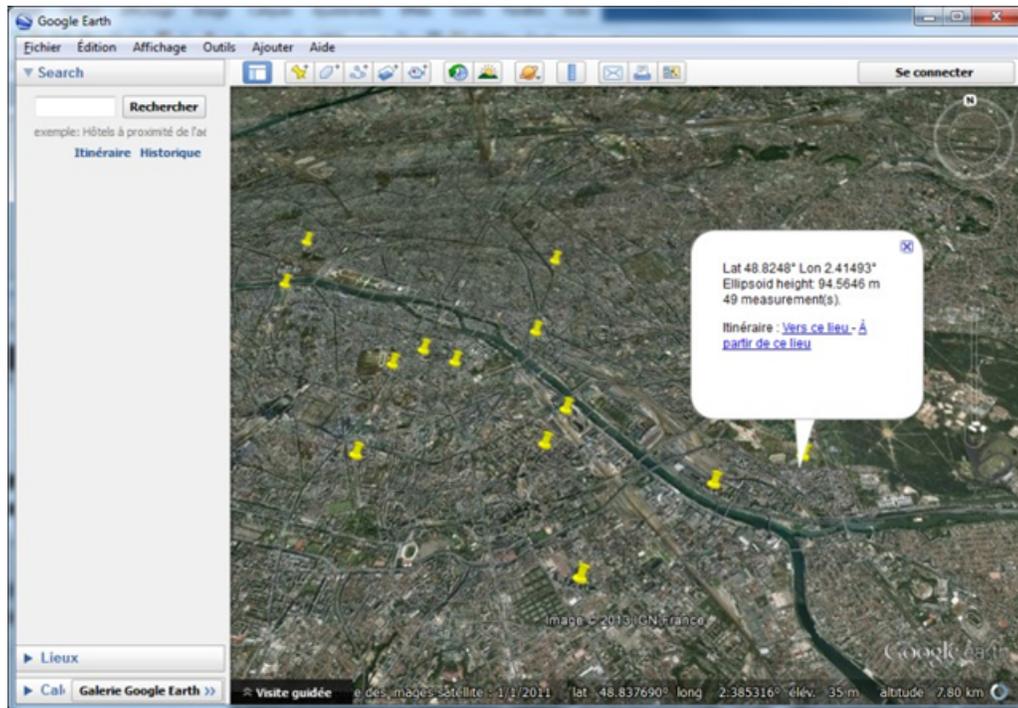


Figure 30:

## Control Point Properties



### Properties

Click on Edit to access Control point properties.

The screenshot shows a dialog box for editing a control point. The fields are as follows:

Name:	9001
Type:	Control Point
Coordinate:	WGS 84
Longitude:	6.53589498
Latitude:	46.65644157
Height:	573.32500000
Check Point:	<input type="checkbox"/>
Category:	Full
Horizontal accuracy:	0.01000000
Vertical accuracy:	0.01000000

Figure 31: Control point properties

### *Name*

Control point alias.

### *Coordinate*

Warning: for georeferenced control points, you must specify ellipsoidal height, and not the height above sea level, if your spatial reference system does not specifically include an orthometric vertical datum. For the WGS 84 reference system, for example, you must enter ellipsoidal heights; if your system is WGS 84 + NAVD 88 geoid height, then you must use heights above sea level.

For more information, please refer to [Useful concepts](#) (on page 15).

Edit the control point 3D position in the corresponding fields. Coordinate units depend on the chosen coordinate system:

- Local coordinate system: same unit for X, Y and Z (known unit or arbitrary unit).
- WGS 84: latitude and longitude in degrees, ellipsoidal height in meters.
- Other: X, Y and height in meters (according to the selected coordinate system).

### *Check point*

Enable this option if you want to use the control point for checking only. In such case the control point will not be considered during the aerotriangulation.

## *Category*

- Full: XYZ coordinates will be used (default).
- Horizontal: only X and Y coordinates will be used.
- Vertical: only Z coordinates will be used.

## *Horizontal accuracy*

Enter the given accuracy for the X and Y coordinates of the control point.

Control points with a higher accuracy will have more weight in the aerotriangulation.

## *Vertical accuracy*

Enter the given accuracy for the Z coordinates of the control point.

Control points with a higher accuracy will have more weight in the aerotriangulation.

## Tie points

**Note:** Once a reconstruction is created in a block, the *Tie points* tab is read-only.

Tie points are 2D correspondences corresponding to a same physical point with unknown coordinate.

The survey tab manages only user tie point ie. tie point defined manually by the user. Note than ContextCapture can automatically generate a large number of automatic tie points during the aerotriangulation process. See Automatic Tie points.

Tie points can be added manually or can be imported. See also Importing tie points (on page 66).

## Usage

Used during the aerotriangulation of a block, user tie points can improve aerotriangulation accuracy and help the aerotriangulation in case of large baseline and ambiguous pattern. In most cases, user tie points are not required, because ContextCapture can cope with using only automatically generated tie points. User tie points should be used only to solve aerotriangulation issues. In all cases, before acquiring user tie points, we recommend to run a first aerotriangulation.

## *Improve photo position*

Some repetitive elements in photos can cause a photo to not be properly positioned.

By defining points that represent the same position in different photos, you can guide the aerotriangulation process towards to correct photo positioning.

## *Group aerotriangulation components*

Sometimes the aerotriangulation cannot connect all the photos due to a too large baseline or scale difference between some images.

With user tie points defined across the picture set, the multi-pass aerotriangulation mode is able to stitch the pictures together. To enable aerotriangulation multi-pass mode, from aerotriangulation settings, set "Component construction mode" to "Multi-pass".

# ContextCapture Master

## Block

---

At least 3 user tie points must be defined in 4 images (2 measures in each component that you want to fuse).

⚠ Adding user tie points increases components connection chances, but the connection is never guaranteed.

### *Add positioning constraints*

Positioning constraints are priors based on user tie points to provide scene origin/scale/orientation. Positioning constraints are used to perform a rigid registration of the block during aerotriangulation.

See also [Geometry constraints](#) (on page 141).

### *Label positions*

You can create user tie points to extract 3D-coordinates of points of interest. Once the scene is calibrated (after Aerotriangulation), ContextCapture can estimate accurately the 3D coordinates from 2D-pointing and can export this information (See Survey export).

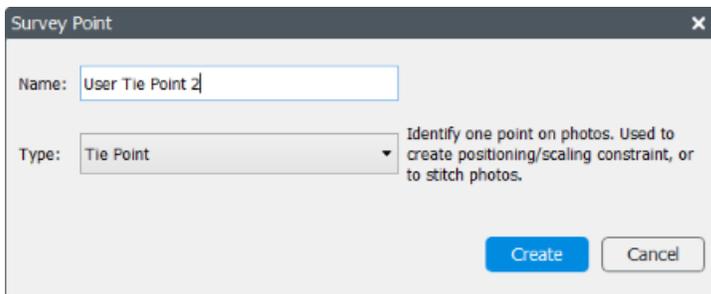
## Adding user tie points

1. Click on Add Survey Point.



2. Define Name.

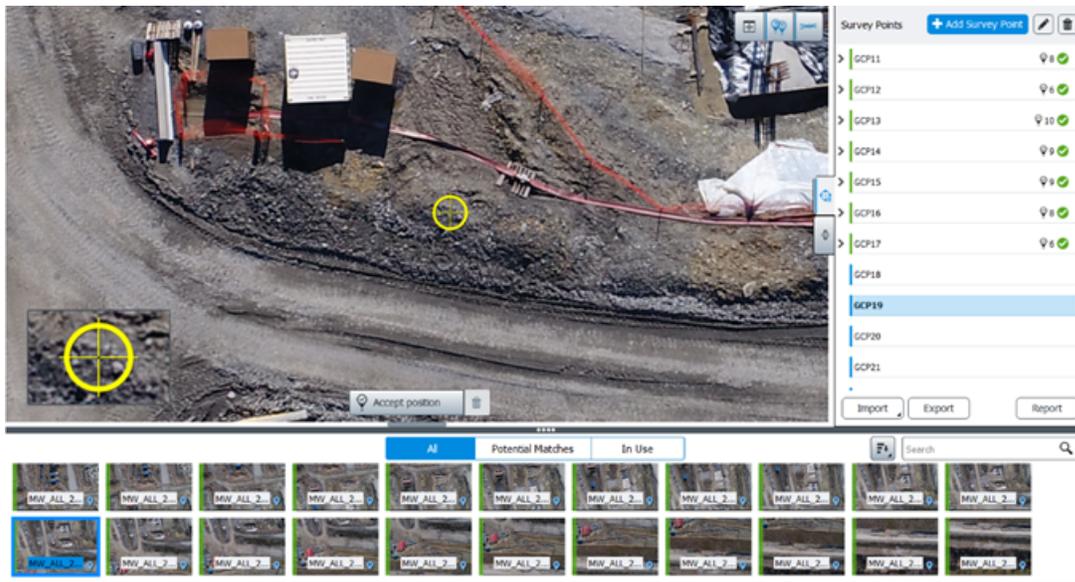
**Note:** We recommend to use an explicit name for each tie point to ease the identification of an individual user tie point (for the constraint definition, etcetera).



3. Select Type Tie Point.
4. Click on Create.  
The new Tie point appears in the list.
5. Place the tie point on photos.  
Select measurement photo displaying the point, define its position in the photo with the yellow marker and click Accept position (alternatively, use Shift+Click to set directly the position on the photo).

# ContextCapture Master

## Block



Repeat the sequence of operations above to set the position on several photos.

## Importing tie points

There are two ways to import tie points:

- With a ContextCapture Surveys file (XML) imported from the survey tab (Import button).
- With the block import: user tie points can be part of the block definition. See also [Import blocks](#) (on page 108).

## Surveys: Positioning Constraints

Positioning constraints are position/orientation/scale priors based on user tie points. They are used to perform a rigid registration of the block during aerotriangulation.

Positioning constraints are used only when using "Use positioning constraints on user tie points" mode during aerotriangulation.

You can set the origin and/or the scale and/or the orientation (either on axis or a plane).

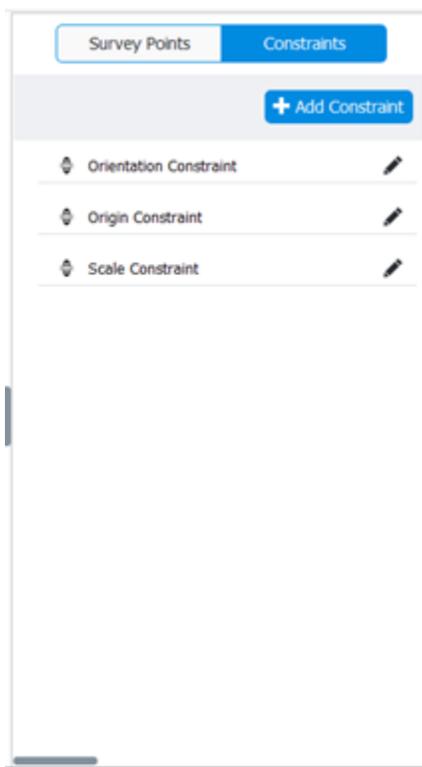


Figure 32: Example of a list of positioning constraints

## Origin constraint

*Add constraint type > Origin constraint*

⚠ You cannot add an origin constraint if another origin constraint exists. Select the point corresponding to the Origin  $O=(0,0,0)$ .

## Scale constraint

*Add constraint type > Scale constraint*

Select two points A and B and specify the distance between them.

Select the distance unit if you know it, or use "units (arbitrary)" if it is not defined.

You can add several scale constraints.

## Axis constraint

*Add constraint type > Axis constraint Orientation*

constraint based on an axis.

Select two points A and B and an axis, line AB being this axis (increasing values from A to B).

# ContextCapture Master

Block

---

⚠ You cannot add an axis constraint if another orientation constraint exists (axis or plane constraint).

## Plane constraint

*Add constraint type > Plane constraint Orientation*

*Constraint based on a plane*

Select three points and two axes to specify a plane.

⚠ You cannot add a plane constraint if another orientation constraint exists (axis or plane constraint).

## Export Surveys

Click on the Export button to export Surveys in various file formats.

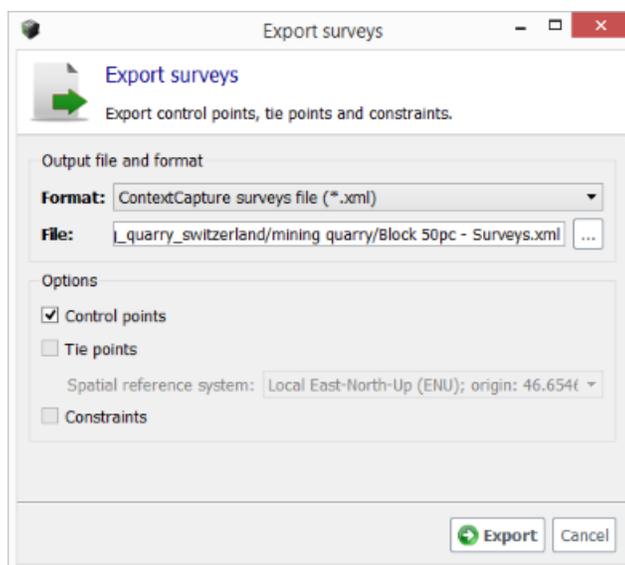


Figure 33: Export Surveys dialog

## KML file

Georeferenced control points or tie points (if ContextCapture can estimate the 3D position) can be exported to a KML file; you then can use this file to visualize the points in a standard GIS tool or in Google Earth.

# ContextCapture Master

Block

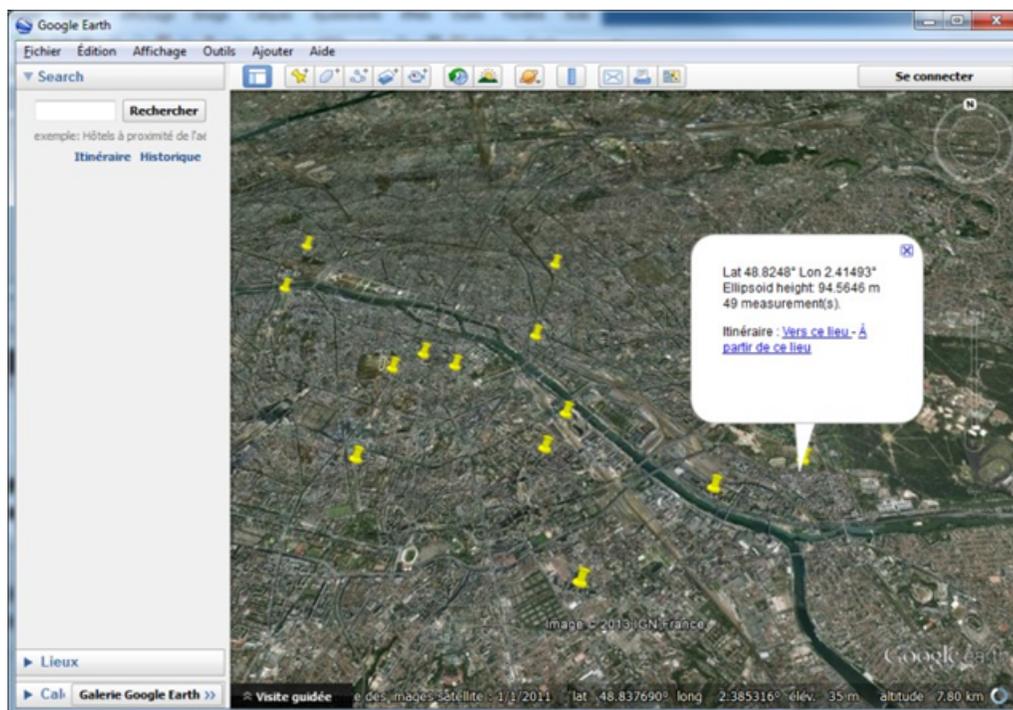


Figure 34: Control points KML export displayed in Google Earth

## Text file

Control points or tie points (if ContextCapture can estimate the 3D position) can be exported to a simple text file with Name and coordinate (X, Y and Z).

Survey points text file sample:

GCP_A	315796.627695945 4869916.09237971 627.8
GCP_B	315332.029686681 4870703.80261219 738.9

## ContextCapture Surveys file (XML)

All surveys data (including survey point properties, position on photos and positioning constraints) can be exported to XML format.

## Tools

ContextCapture provides various tools to ease the survey points acquisition: filters or sorts, display hints, etcetera.

### Photos filter

Use these options to apply filters on the list of photos.

### Status filters

# ContextCapture Master

Block

---

This filter allows to select photos according to their status for the selected Survey point.



## All

Display all photos

Disables filtering according to status for the selected survey point.

## Potential Matches

Display only recommended photos, on which the selected survey point may be placed.

It uses the available positioning data of the block to find the photos.

**Note:** In some cases, it may be interesting to process a first aerotriangulation with an approximate georeferencing based on GPS tags or on few control points to be able to take advantage of the selection mode based on block orientation, and then acquire the entire control point set more easily.

**Note:** Potential Matches filter works for photos with known photogroup properties and pose.

Incomplete block photos are not handled when using this selection mode.

ContextCapture takes advantage of the available block data, including the current survey data to improve potential matches estimation: on a calibrated scene, potential matches become more relevant after adding the first survey points (typically from the 4th).

In Use

Display only photos where a position is already registered for the selected survey point.

Sort



Two sorting modes are available:

- Alphabetical: photos are sorted by name, alphabetically.
- Distance from point: for a control point, closest photos are displayed first (ignoring rotation).

Filter by name

Allow to select photos by name.



## Image display options

These options allow to control the content of the image view.



Show/hide all potential positions

Show the potential position of all survey points on the current photo.

For the selected survey point, the potential position is displayed with the placement marker (in yellow).

For other surveys points, the potential positions are displayed with orange markers.

# ContextCapture Master

Block

---



Show/hide potential position of the current point

Enable epipolar lines display to highlight the potential matching region, or to check the survey point quality.

**Note:** We recommend to process a first aerotriangulation, to be able to take advantage of the selection mode based on block orientation. This will greatly ease the process of defining user tie points.

**Note:** The display photo filter based on block orientation works for photos with known photogroup properties and pose.

## Quality control

After aerotriangulation you can use the control point editor in order to control the positioning quality or to identify errors.

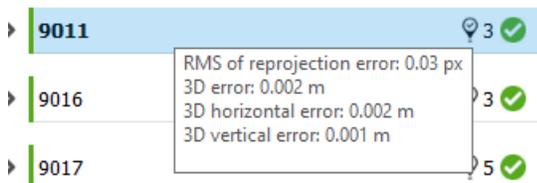
You can get statistics for each point, for each measurement or for each photo, or global statistics.

You can get global statistics from the Survey Report.

## Survey point items

You can get statistics for each survey point item, and for each measurement item: item border is colored according to the reprojection error (see Reprojection error).

Additional statistics are available from the item tooltip.



Quality metrics on a survey point item (colored border and tooltip)

## Survey report

Click Report to display the Survey report.

# ContextCapture Master

## Block

Control points		User tie points											
Number of points: 7		Number of points: 0											
- RMS of reproj. error: 0.03 px - RMS of 3D error: 0.003 m - RMS of 3D horizontal error: 0.002 m - RMS of 3D vertical error: 0.001 m													
Name	Position(s) Placed	Category	X (Long)	Y (Lat)	Z (Height)	Coordinate system	Horizontal accuracy [m]	Vertical accuracy [m]	RMS of reproj error [px]	3D error [m]	3D horizontal error [m]	3D vertical error [m]	
1	9017	5	Full	6.5426002	46.65364415	465.026	WGS 84	0.01	0.01	0.0485161	0.00418653	0.00418687	0.000217624
2	9016	3	Full	6.5396989	46.65305217	455.266	WGS 84	0.01	0.01	0.0101632	0.00176346	0.00123488	0.00125891
3	9012	5	Full	6.54184116	46.65325332	460.896	WGS 84	0.01	0.01	0.0341534	0.00310791	0.00292581	-0.00104821
4	9011	3	Full	6.54370093	46.6553795	473.329	WGS 84	0.01	0.01	0.0256742	0.00218388	0.00175923	0.001294
5	9004	6	Full	6.53314731	46.65483476	565.699	WGS 84	0.01	0.01	0.0077504	0.000346626	0.000295391	-0.000181366
6	9002	3	Full	6.53511384	46.65698879	568.726	WGS 84	0.01	0.01	0.0381386	0.0022435	0.00223462	-0.000199373
7	9001	4	Full	6.53589498	46.65644157	573.325	WGS 84	0.01	0.01	0.0432343	0.00259622	0.00207885	0.00155524

## Quality metrics

### Reprojection error

Reprojection error in pixels.

All items are colored according to this value (or to the RMS of this value), with the following rules:

Reproj. error[px]	Accuracy level	Color code
unknown	unknown	blue
<1 px	high	green
[1 px, 3 px]	medium	yellow
> 3 px	low	red

### 3D error

Distance in meters (or units) between the given 3D position and the estimated 3D position.

### Horizontal error

Horizontal distance in meters (or units) between the given 3D position and the estimated 3D position.

### Vertical error

Vertical distance in meters (or units) between the given 3D position and the estimated 3D position.

## Block 3D view

The 3D view tab allows the user to visualize and control block's 3D data.

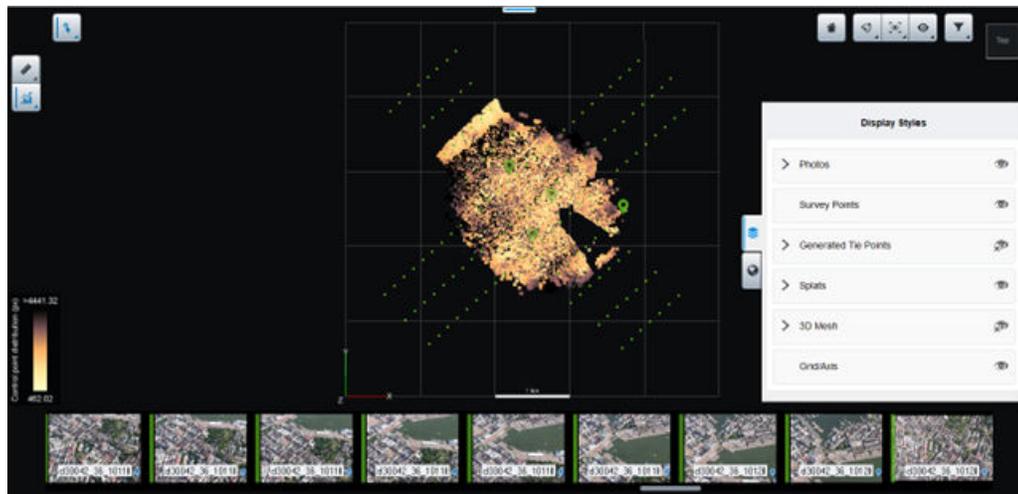


Figure 35: Block 3D view

After aerotriangulation, the 3D model is enriched with generated tie points and splats. See also Splats.

Use the mouse buttons to navigate the 3D scene.

Double-click to focus the navigation on any point of the 3D scene. Click on the photos to display details.

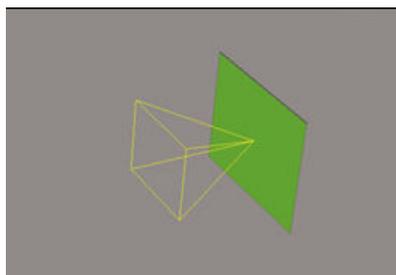
## Contents

Block 3D view content depend on the available data of the block. Content display can be controlled from the Display Styles drawer.

## Photos

Only photos with known position are displayed in the 3D view.

Photos with complete pose (known position and rotation) are displayed with their oriented view frustum, selecting them allows to display their approximated field of view in 3D.



Photos are colored according to their calibration status and to the RMS of reprojection of their tie points.

Color	Reprojection error (px)	Calibration status
	< 1px	Calibrated

# ContextCapture Master

Block

	[1 px, 3px[	Calibrated
	> 3 px	Calibrated
	Unknown	Not calibrated (in a non-calibrated block)
	Unknown	Not calibrated (in a calibrated block)
	Unknown	Calibrated*

(\*) May occur for imported photos without tie points

## Survey points

Survey points symbols allows to identify the survey point type (user tie points or survey points, check point):

Color	Reprojection error (px)
	Control point (used for calibration)
	Control point "Check point" (not used for calibration)
	User tie point (used for calibration)
	User tie point "Check point" (not used for calibration)

Control points are located in the 3D view according to their actual 3D position; user tie points are located on their estimated 3D position.

Survey points are colored according to the RMS of reprojection error of their measurements in input photos:

Color	Reprojection error (px)
	< 1px
	[1 px, 3px[
	> 3 px
	Unknown error

# ContextCapture Master

Block

	Invalid survey point*
---	-----------------------

(\*) Not enough measurements

You can control camera size from the Display Styles drawer.

## Generated Tie points

Colored tie points generated by aerotriangulation.

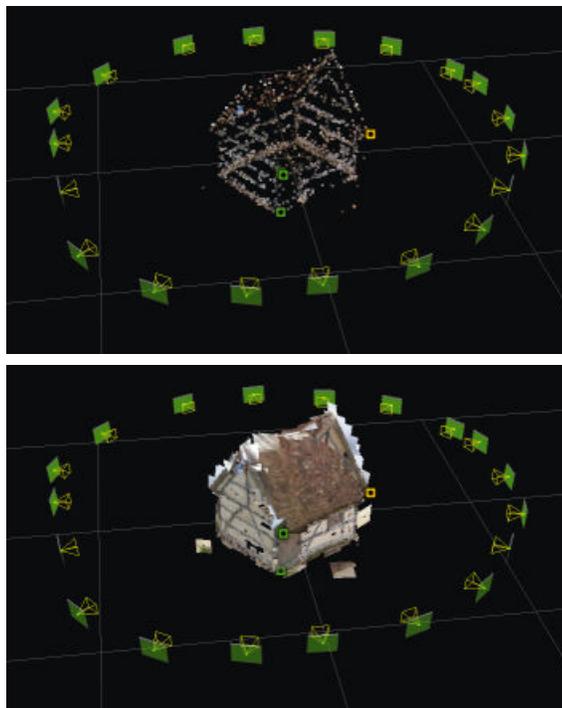
You can control point size from the Display Styles drawer.

## Splats

Splats are an alternative representation of the tiepoints that adds textured surfaces to each point to provide a better understanding of the 3D context (represented scene). Each tie point is depicted as a flat square covered by part of a photo seeing the point.

Splats are processed by default during the aerotriangulation step. However, processing also can be started manually from the block general tab.

Show and hide splats from the Layers menu, and control splats size using the dedicated slider.



*Figure 36: Generated tie points and corresponding splats representation*

Please note that splats do not reflect the quality of the Reality Mesh and are meant only to help understanding tie points positioning.

You can control splats size from the Display Styles drawer.

## Point clouds

Block's point clouds imported from scans.

# ContextCapture Master

## Block

---

You can control point size from the Display Styles drawer.

### 3D Mesh

Allows to display a 3D mesh produced from this block.

Display Styles:

- Source: select which mesh to display among supported block productions (supported formats: 3MX, 3SM).
- Style: select a predefined style to set wireframe and texture combination.
- Backface culling: hides sides of the model facing away from the camera, it may be used to ease navigation in interior scenes.

### Annotations

Annotations are a specific production type extracting automatically information from reality data using ContextInsights AI technology.

Several types of annotations exist but all of them cannot be viewed in 3D:

- 2D Objects
- 3D-Objects
- 2D Segmentation
- Segmented mesh

are the annotation-types viewable in the 3D-view.



Figure 37: 2D Objects

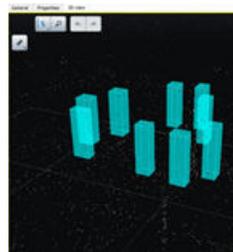


Figure 38: 3D Objects

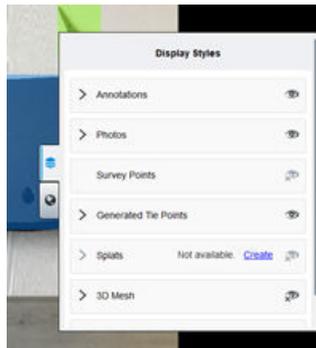


Figure 39: 2D Segmentation



Figure 40: Segmented Mesh

In 3D-View, Annotations can be shown, hidden or filtered by class using the display style tab. It is also possible to overlay 3D-objects annotations onto a mesh that would be part of the same reconstruction.



## Grid/Axis

Base grid and axis can be used to check roughly scene scale and alignment.

# ContextCapture Master

Block

---

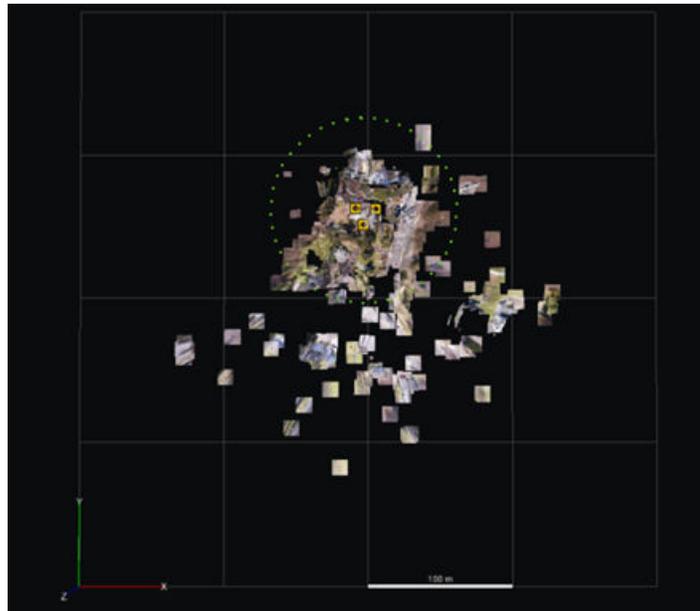


Figure 41: Example of grid and axis

## Basemap

Basemaps allows to add reference 3D contents in the 3D view.

You can also add and manage basemap layers with the Basemap manager. (See also Basemap manager on page 37.)



Figure 42: Example of basemap created from local data

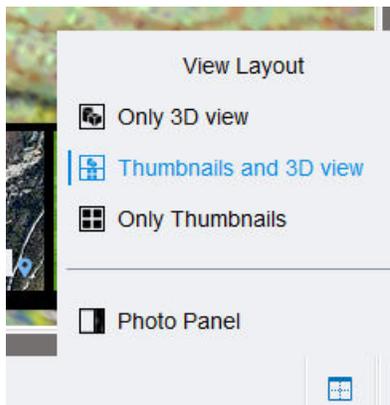
## Photo Navigation

Use this command to activate Photo Navigation.

See also Photo Navigation.

## View Layout

Block view layout includes 3D view, thumbnails and photo panel. Use the view layout commands to switch between the proposed modes.



View layout menu

### 3D view

Main view, it can be combined with thumbnails and photo panel.

Use the Display Styles drawer to control the 3D view contents.

### Thumbnails

List all block photos and point clouds, including items not represented in the 3D view (photo without poses, etc.).

Thumbnails view can be maximized with the Only Thumbnails mode, to ease photos browsing.

### Photo Panel

Full resolution display of a selected photo.

## Selection Tools

Selection tools allow to select 3D objects to apply various actions.

Use the single selection tool to select one item, or the rectangle tool to select a set of objects.

You can control the type of object to select with the selection filter.

Selectable objects and corresponding actions are:

- Photos: display properties, enable view frustrum display, zoom on item, delete.
- Tie points: display/select associated cameras and delete.
- Survey points: display/select associated cameras and delete

Selection can be also extended or modified with Shift or Ctrl keys.

## Navigation Modes

Shift between Orbit and Pan mode to select how to control the camera with mouse buttons.

### Lock on Photo

This mode activates an immersive view of the scene through a selected photo.

Photo is aligned on the scene thanks to photo and photogroup parameters (pose and optical properties).  
Navigation is locked on photo viewpoint.

Use Photo overlay settings to change image plane depth and opacity.

Lock on photo shows simultaneously 3D objects and photographs in a same space. Using photos aligned on 3D model allows to cross-compare 3D data with reference data (quality control, etc.), and enhances 3D views with reliable context and details.

Example of applications:

- Understand acquisition/scene.
- Check 3D data alignment with photos: scan, tie points, mesh, etcetera.
- Identify/understand reality mesh misconstructions.
- Enhance 3D view inspection: details, context, etcetera.

### Photo Navigation

Use this mode to link the 3D models and the photos. You can navigate through the photos and see the fit to corresponding viewpoints in the 3D model.



Figure 43: Photo Navigation mode

Enable the photo panel from the View Layout menu for a better user experience.

Click on the 3D model or on the photo panel to specify a target point, get the best photos viewing this point in the bottom ribbon, and locate the target simultaneously on the 3D model and on the photo.

# ContextCapture Master

## Block

---

The selected photo on the right fits to the selected target in the 3D view. Use the auto-sync photo panel mode to synchronize photo when target is moved in the 3D view.

View point in the 3D view fits the selected target in the photo. Use the auto-sync 3D view mode to synchronize 3D display when target is moved on the photo. Use the Zoom on photo button to reset initial view point in the 3D view on the selected target in the photo.

Thumbnails show the photos actually viewing the target and sorted by preference. Disabling the target restores all photos.

Enable Fast Filtering mode to ignore occlusion for photo filtering and sorting.

In Photo Navigation mode you also can display a 3D model previously produced from this block if the format is supported. You can select the displayed 3D mesh from the Display Styles drawer.

### Filter Tools

Filter photos by name or by camera device (photogroup).

### Display Styles

The drawer controls the visibility and display style of the 3D view items.

Some options may be disabled according to the displayed data.

See also chapter Block 3D view > Contents.

### Basemaps

Basemaps drawer allows you to add and manage basemap layers. (See also [Basemap manager](#) (on page 38).)

### Measurement Tools



#### Measurements

Opens the measurement tool.

The following measurements are available:

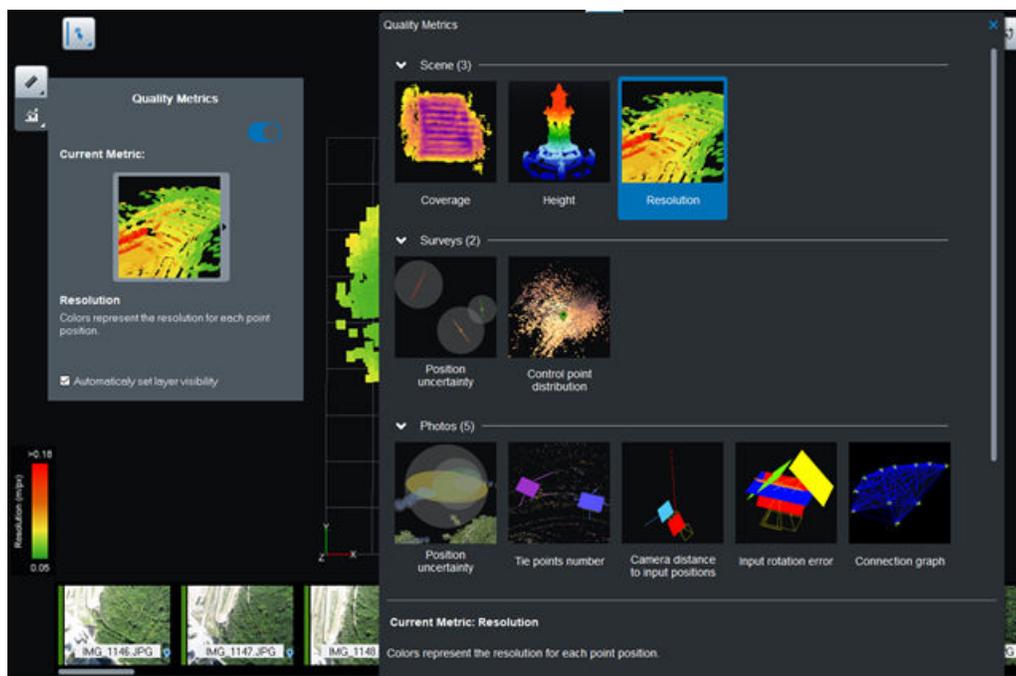
- Location: get accurate 3D coordinates of a point in a given coordinate system.
- Distance: get 3D distance and height difference between two points.
- Area: get polygon area and contour length.
- Volume: get volume measurement between the 3D model and a reference plane in a polygon.

### Quality Metrics

The Quality Metrics allows a quick 3D analysis of aerotriangulation result. A variety of metrics are proposed, ranging from scene coverage to position uncertainty for photos and survey points.

Access the metrics by clicking on the "Quality Metrics" button: .

Subsequently, click on the metric thumbnail to access the entire list of metrics.



Click on the metric thumbnail to access the entire list of metrics.

The Quality Metrics dialog, with the current metric and the list of all available metrics.

Proposed metrics:

## 1. Scene

- Coverage: indicates the number of photos that potentially see each area. Note: occlusions are ignored, points that are hidden by other parts of the scene are considered as visible if they are in the field of view of the photo.
- Height: colors the generated tie points according to their vertical position.
- Resolution: displays the ground resolution (in 3D units/px) for each generated tie point.

## 2. Surveys

- Position uncertainty: exposes a visual representation of how certain are the image positions of each survey point. Transparent spheres around the survey points indicate how uncertain is the position (scaled for readability). Colored ellipses show the most uncertain direction and its magnitude. Note: only available if surveys are present in the scene.
- Control point distribution: indicates how far from a control point are the generated tie points. To calculate this distance, we consider the photos and the link between photos. Note: only available if control points are present in the scene.

## 3. Photos

- Position uncertainty: illustrates to what point the ContextCapture optimization is certain of the estimated photo positions. Transparent spheres around photos indicate the position uncertainty (scaled for readability). Colored ellipses show the most uncertain direction and its magnitude.
- Number of tie points: colors the photos according to the number of tie points linked to them.
- Distance to input positions: shows the offset between the input positions and the computed photo positions. Colors indicate the magnitude, and lines indicate the direction of the change in position. Note: only available if input positions are provided.

# ContextCapture Master

Block

---

- Distance to input rotations: illustrates the difference between the input rotations and the computed photo rotations. Colors indicate the angle difference. Note: only available if input rotations are provided.
- Connection graph: displays links between photos; two photos are paired together if they have tie points in common.

## 4. Tie Points

- Number of observing photos: represents the number of photos that have been used to define each point, smoothed over the set of photos seeing the point. The averagemean value is used in order to provide a comprehensive information about the scene and filter noisy data.
- Reprojection error: considers the pixel reprojection error for each tie point.
- Position uncertainty: indicates the individual tie point position uncertainty, averaged over the photos seeing the point. This metric illustrates how well placed can we expect the generated tie point to be after the ContextCapture optimization.

## Lock on Photo

This mode activates an immersive view of the scene through a selected photo.

Photo is aligned on the scene thanks to photo and photogroup parameters (pose and optical properties). Navigation is locked on photo viewpoint.

Use Photo overlay settings to change image plane depth and opacity.

Lock on photo shows simultaneously 3D objects and photographs in a same space. Using photos aligned on 3D model allows to cross-compare 3D data with reference data (quality control, etc.), and enhances 3D views with reliable context and details.

Example of applications:

- Understand acquisition/scene.
- Check 3D data alignment with photos: scan, tie points, mesh, etcetera.
- Identify/understand reality mesh misconstructions.
- Enhance 3D view inspection: details, context, etcetera.

## Photo Navigation

Use this mode to link the 3D models and the photos. You can navigate through the photos and see the fit to corresponding viewpoints in the 3D model.



Figure 44: Photo Navigation mode

Enable the photo panel from the View Layout menu for a better user experience.

Click on the 3D model or on the photo panel to specify a target point, get the best photos viewing this point in the bottom ribbon, and locate the target simultaneously on the 3D model and on the photo.

The selected photo on the right fits to the selected target in the 3D view. Use the auto-sync photo panel mode to synchronize photo when target is moved in the 3D view.

View point in the 3D view fits the selected target in the photo. Use the auto-sync 3D view mode to synchronize 3D display when target is moved on the photo. Use the Zoom on photo button to reset initial view point in the 3D view on the selected target in the photo.

Thumbnails show the photos actually viewing the target and sorted by preference. Disabling the target restores all photos.

Enable Fast Filtering mode to ignore occlusion for photo filtering and sorting.

In Photo Navigation mode you also can display a 3D model previously produced from this block if the format is supported. You can select the displayed 3D mesh from the Display Styles drawer.

## Filter Tools

Filter photos by name or by camera device (photogroup).

## Display Styles

The drawer controls the visibility and display style of the 3D view items.

Some options may be disabled according to the displayed data.

See also chapter Block 3D view > Contents.

## Basemaps

Basemaps drawer allows you to add and manage basemap layers. (See also [Basemap manager](#) (on page 38).)

## Measurement Tools



### Measurements

Opens the measurement tool.

The following measurements are available:

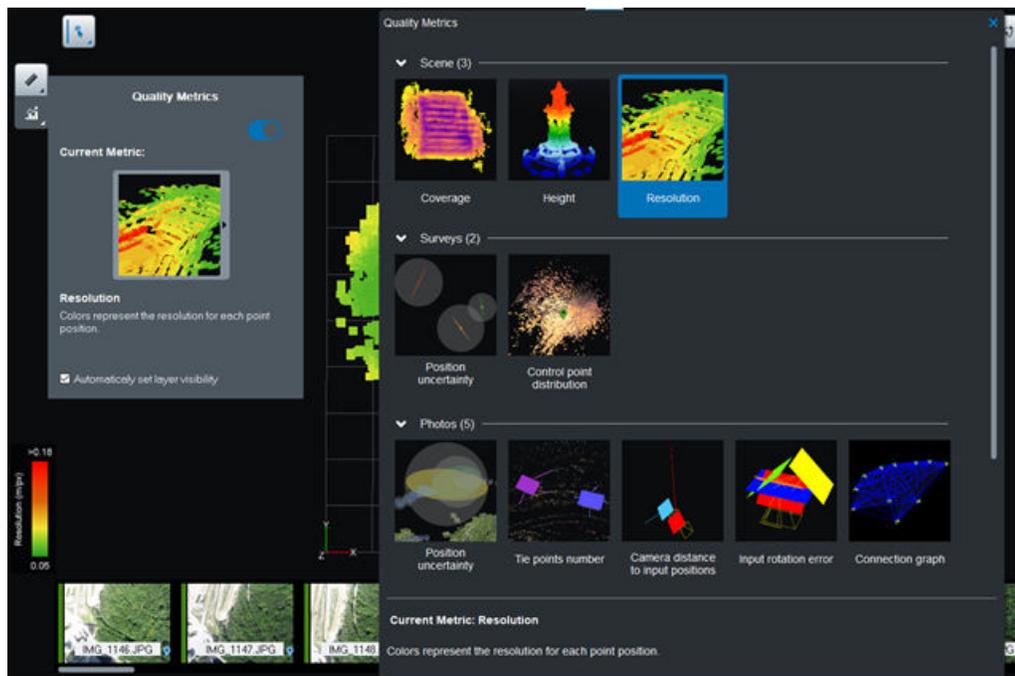
- Location: get accurate 3D coordinates of a point in a given coordinate system.
- Distance: get 3D distance and height difference between two points.
- Area: get polygon area and contour length.
- Volume: get volume measurement between the 3D model and a reference plane in a polygon.

## Quality Metrics

The Quality Metrics allows a quick 3D analysis of aerotriangulation result. A variety of metrics are proposed, ranging from scene coverage to position uncertainty for photos and survey points.

Access the metrics by clicking on the "Quality Metrics" button: .

Subsequently, click on the metric thumbnail to access the entire list of metrics.



Click on the metric thumbnail to access the entire list of metrics.

The Quality Metrics dialog, with the current metric and the list of all available metrics.

Proposed metrics:

## 1. Scene

- Coverage: indicates the number of photos that potentially see each area. Note: occlusions are ignored, points that are hidden by other parts of the scene are considered as visible if they are in the field of view of the photo.
- Height: colors the generated tie points according to their vertical position.
- Resolution: displays the ground resolution (in 3D units/px) for each generated tie point.

## 2. Surveys

- Position uncertainty: exposes a visual representation of how certain are the image positions of each survey point. Transparent spheres around the survey points indicate how uncertain is the position (scaled for readability). Colored ellipses show the most uncertain direction and its magnitude. Note: only available if surveys are present in the scene.
- Control point distribution: indicates how far from a control point are the generated tie points. To calculate this distance, we consider the photos and the link between photos. Note: only available if control points are present in the scene.

## 3. Photos

- Position uncertainty: illustrates to what point the ContextCapture optimization is certain of the estimated photo positions. Transparent spheres around photos indicate the position uncertainty (scaled for readability). Colored ellipses show the most uncertain direction and its magnitude.
- Number of tie points: colors the photos according to the number of tie points linked to them.
- Distance to input positions: shows the offset between the input positions and the computed photo positions. Colors indicate the magnitude, and lines indicate the direction of the change in position. Note: only available if input positions are provided.
- Distance to input rotations: illustrates the difference between the input rotations and the computed photo rotations. Colors indicate the angle difference. Note: only available if input rotations are provided.
- Connection graph: displays links between photos; two photos are paired together if they have tie points in common.

## 4. Tie Points

- Number of observing photos: represents the number of photos that have been used to define each point, smoothed over the set of photos seeing the point. The averagemean value is used in order to provide a comprehensive information about the scene and filter noisy data.
- Reprojection error: considers the pixel reprojection error for each tie point.
- Position uncertainty: indicates the individual tie point position uncertainty, averaged over the photos seeing the point. This metric illustrates how well placed can we expect the generated tie point to be after the ContextCapture optimization.

## Additional data

The Additional data tab allows you to edit or display additional knowledge on the acquisition which is used to help aerotriangulation.

**Note:** Once a reconstruction is created in a block, the *Additional* tab is read-only.

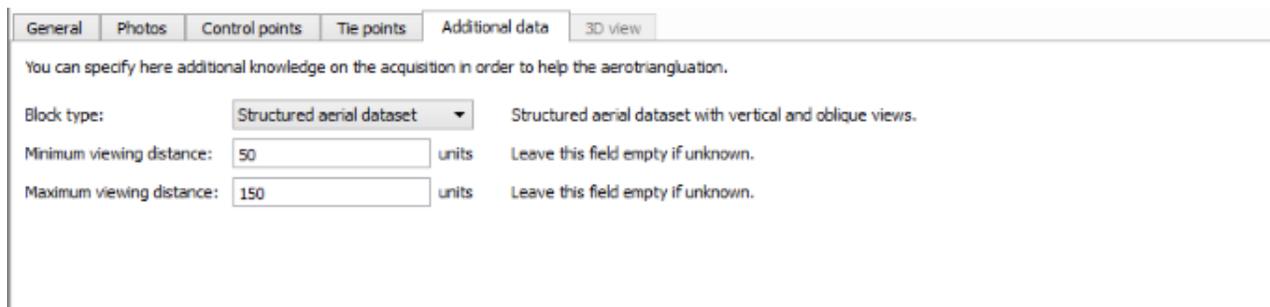


Figure 45: The Additional data tab

## Block type

This advanced option allows you to specify some typical acquisition types:

- Generic (default): advised for most image datasets.
- Vertical views only: advised for any aerial image dataset made of vertical views only (pointing toward the bottom).

Also named *Nadir block type*.

- Structured aerial dataset: advised for structured aerial image datasets only, with vertical and oblique views acquired with a regular sweep of the area in parallel lines, and sensors with fixed lever arm angles.

Also named *Aerial block type*.

- Orbit around thin vertical structure: advised for dataset made of orbital views around a thin structure or around a thin vertical subject of interest in the foreground (telecommunication tower, pylon, wind turbine, etc.).

Also named *Orbit block type*.

## Minimum/maximum viewing distance

Allows to specify a rough estimate of the viewing distance:

- Minimum viewing distance
- Maximum viewing distance

If your knowledge about the viewing distance is approximative, please take an appropriate margin (reduce the minimum viewing distance and increase the maximum viewing distance accordingly).

When the photo positions are known, the minimum and maximum viewing distances can be used during aerotriangulation to discard inadequate pairs of photos and improve performance.

## Aerotriangulation

To perform the 3D reconstruction from photographs, ContextCapture must know very accurately the photogroup properties of each input photogroup and the pose of each input photograph. If you ignore these properties, or if you do not know them with sufficient accuracy, ContextCapture can automatically estimate them by a process called aerotriangulation - or aerial triangulation - sometimes abbreviated to AT.

The aerotriangulation starts from an input block, and produces a new block with computed or adjusted properties.

## ContextCapture Master

### Block

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The aerotriangulation can take into account current camera positions (e.g., initialized from GPS), or control points for georeferencing.

Although ContextCapture can compute an aerotriangulation without initial information about the pose of input photographs, it is not recommended for a very large number of photos; in this case the aerotriangulation without any input positioning is unlikely to give satisfying results. Massive datasets should preferably include approximate pose information (e.g. INS) and should be [Aerotriangulation](#) (on page 87). ContextCapture can then adjust a very large imported block by aerotriangulation, the only limit in block size being computer memory.

### Creating a new block by aerotriangulation

From the block *General* tab or from the context menu of the Project tree view, click on *Submit aerotriangulation* to create a new block by aerotriangulation.



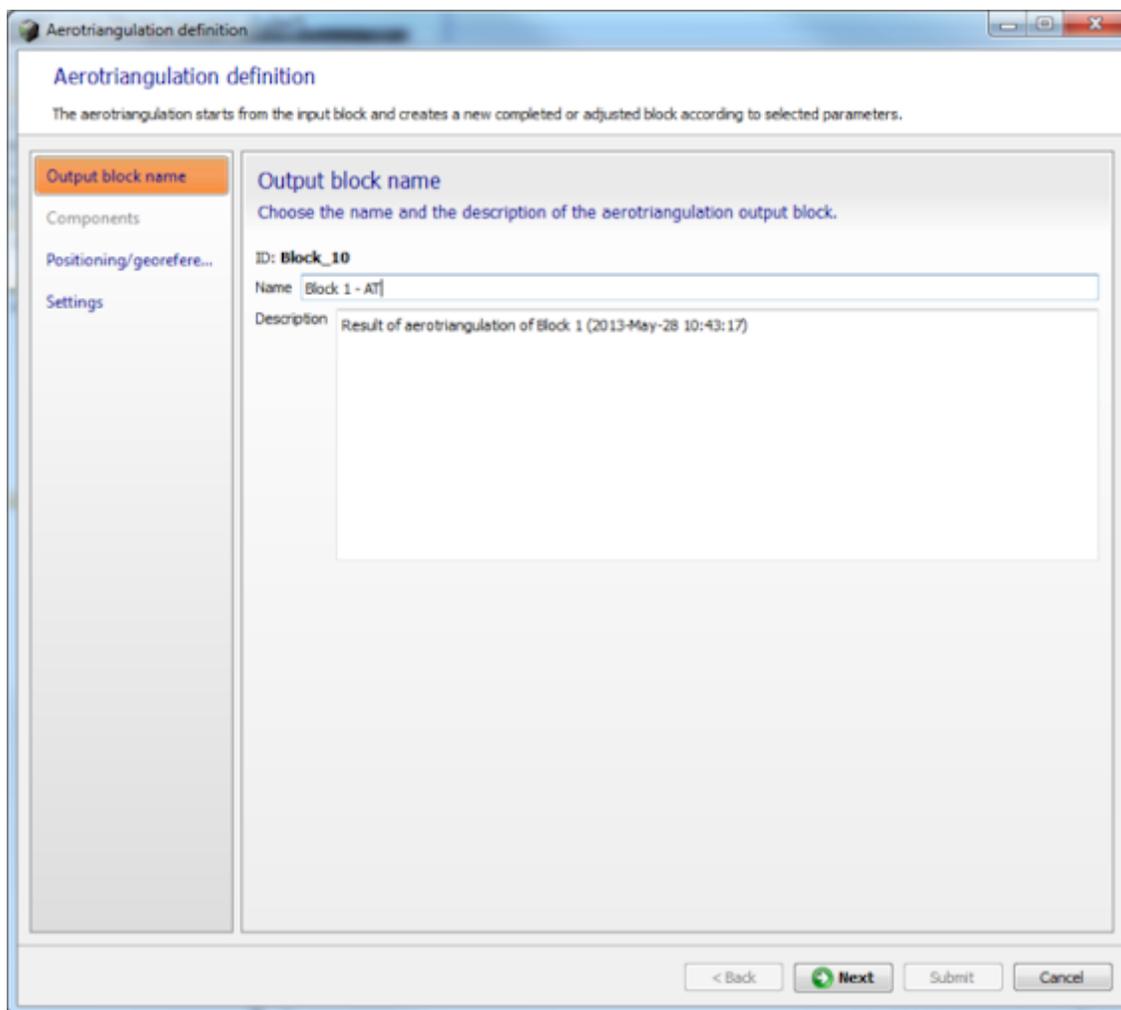
*Process a new block with completed or adjusted parameters.*

### Output block name

*Choose the name and the description of the aerotriangulation output block.*

# ContextCapture Master

## Block



## Components

*Select photos to consider for the aerotriangulation according to their component.*

This page is enabled only if the block contains photos belonging to different components.

Select photos to consider for the aerotriangulation:

- Use all photos: Include photos not belonging to the main component in the aerotriangulation. This may be useful to incorporate in the main component photos which were newly added to the block, or photos which were discarded by a previous aerotriangulation.
- Use only photos of the main component: photos outside of the main component will be ignored by the aerotriangulation. This may be useful to perform a new accurate adjustment on the set of photos successfully matched by a previous aerotriangulation.

# ContextCapture Master

Block

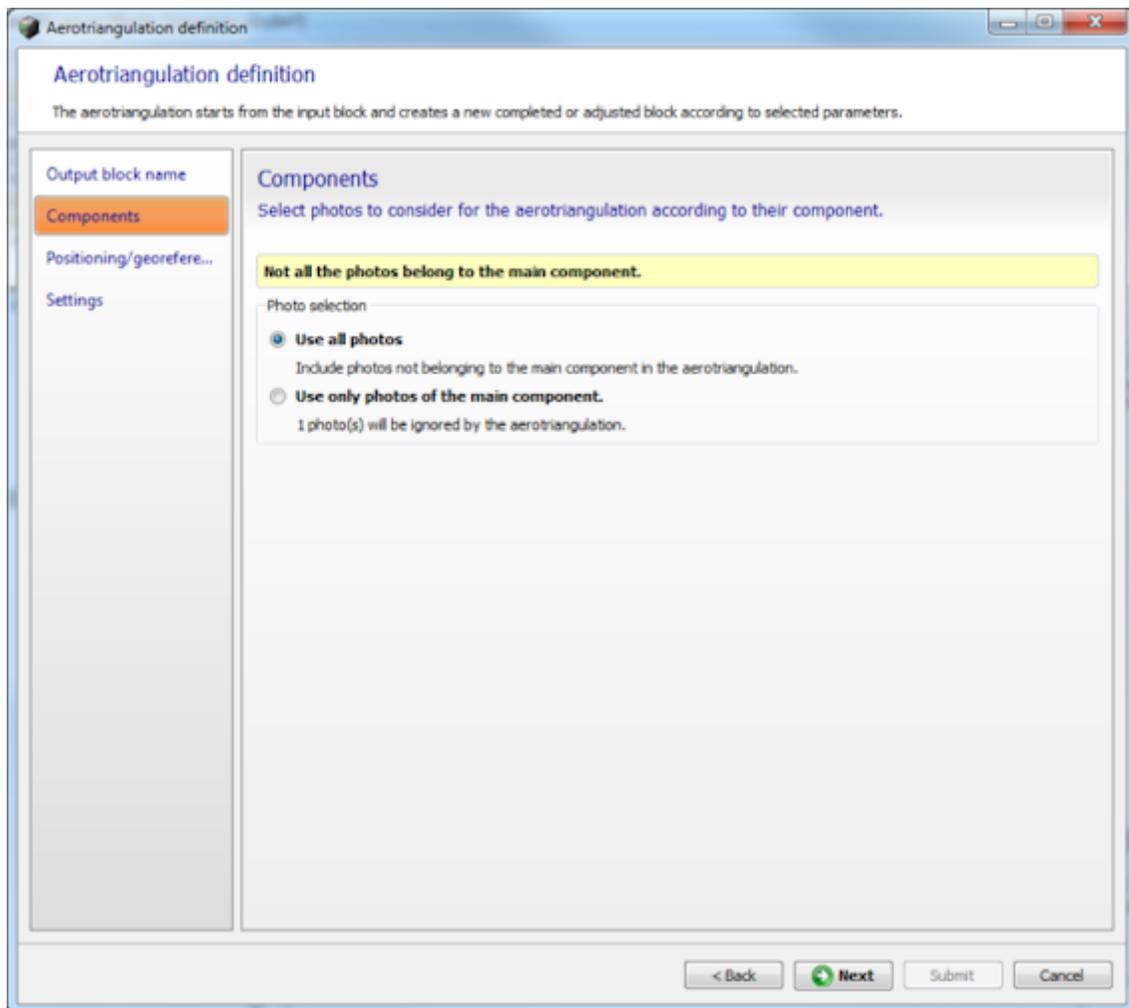


Figure 46: Aerotriangulation components selection

## Positioning/georeferencing

Choose how the aerotriangulation should adjust and orient the block.

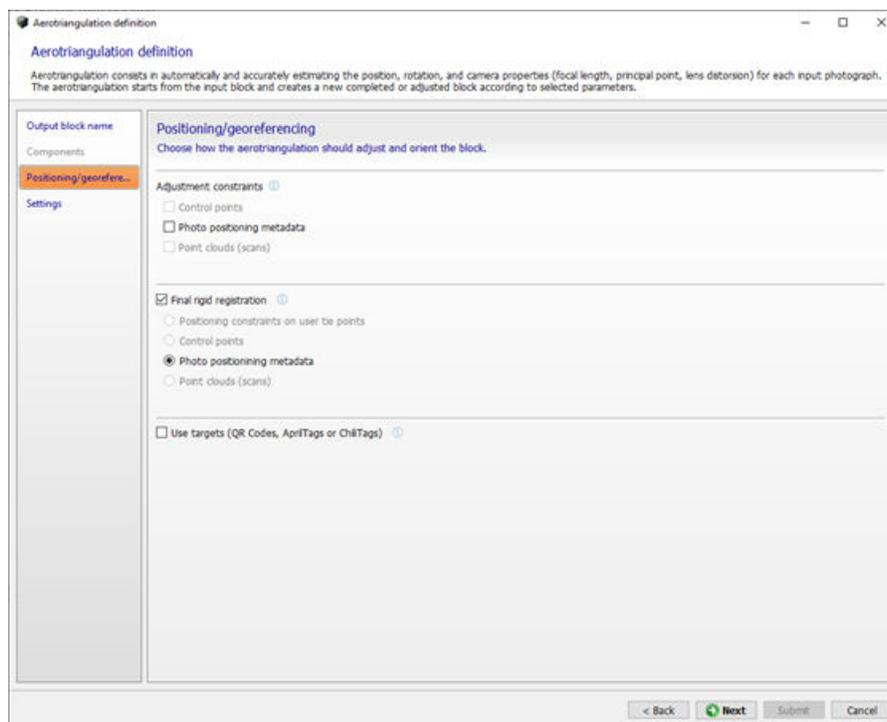


Figure 47: Aerotriangulation positioning/georeferencing parameters

Positioning modes are enabled according to input block properties.

Aerotriangulation can work with positioning constraints but in this case, block position and orientation are arbitrary.

### *Adjustment constraints:*

- Control points (need a valid control point set): The block is accurately adjusted to control points (advised when control points accuracy is consistent with the resolution of input photos).
- Photo positioning metadata (available only if the input block has at least 3 photos with positioning metadata): the block is accurately adjusted according to the photo positions from the pose metadata (advised with accurate metadata).
- Point clouds (scans).

### *Final rigid registration:*

- Positioning constraints on user tie points (available only if the input block has positioning constraints): the block is rigidly placed/oriented/scaled thanks to the predefined constraints.
- Photo positioning metadata for rigid registration (available only if the input block has at least 3 photos with positioning metadata): the block is rigidly registered to photo positions from pose metadata (advised with inaccurate metadata).
- Control points (need a valid control point set): The block is rigidly registered to control points without handling long range geometric distortion (advised for inaccurate control points).
- Point clouds (scans).

# ContextCapture Master

## Block

### *Use targets (QR Codes, AprilTags or ChiliTags)*

Allows to register block with positioning constraints or control points from targets extracted from photos. Current survey data is also used.

For positioning modes using control points, a valid control point set is needed on selected photos: *at least 3 control points with more than 2 measurements each.*

Learn more about targets creation ContextCapture [ContextCapture Target Creator](#) (on page 212) [page 189].

## Settings

*Choose aerotriangulation estimation methods and advanced settings.*

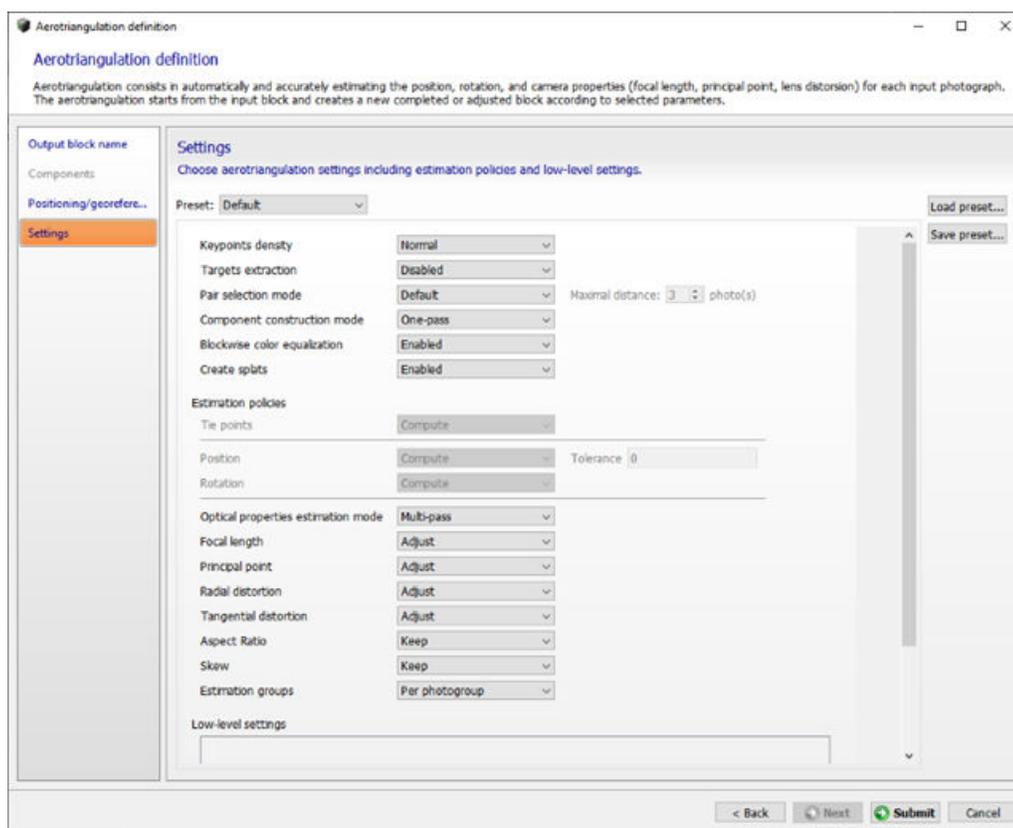


Figure 48: Aerotriangulation settings

### Presets

Presets manage all settings accessible in the user interface and may include low level settings used to control accurately aerotriangulation algorithms.

Presets can be used to save and load user settings or to setup predefined configurations.

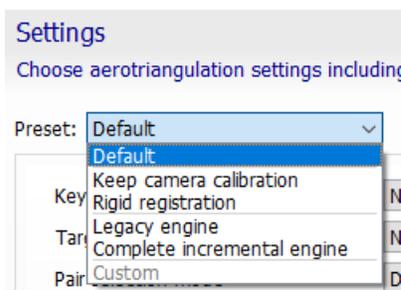


Figure 49: Activating the alternate aerotriangulation engine

## Default engine

Use this preset to activate the latest ContextCapture engine.

## Legacy engine

Use this preset to activate the engine of previous updates.

## Complete incremental engine

Use this preset to allow the engine to start from the current result, if any, to save missing photos or connect some existing components.

## Keypoints density

Keypoints density value can be changed to manage a specific dataset:

- Normal: advised for most datasets.
- High: increase the number of keypoints, advised to match more photos in cases where the subject has insufficient texture or the photos are small. This setting makes the aerotriangulation processing slower.

We recommend you to try the *Normal* mode first.

## Target extraction

Defines the type of targets to be extracted from the images.

- Disabled: no target will be extracted.
- QR Codes: Regular QR codes and ContextCapture User Tie Point QR codes will be used to create user tie points. ContextCapture Control Point QR codes will be used to create control points.
- April Tags: will be used to create user tie points or to mark an existing control point.
- Chili Tags: will be used to create user tie points or to mark an existing control point.

## Pair selection mode

Tie points pairs may be computed using different selection algorithms:

- Default: selection is based on several criteria, among which similarity between images.
- Similar images only: estimate relevant pairs by keypoint similarity. It gives good results with a reasonable computation time when image similarity is discriminative enough.
- Exhaustive: use all possible pairs, advised in cases where the overlap between photos is limited (e.g., for a camera rig). Exhaustive selection computation is a lot more intensive (quadratic rather than linear), so it should be reserved to a small number of photos (a few hundreds).
- Sequence: use only neighbor pairs within the given distance, advised for processing a single sequence of photos if the Default mode has failed. The photo insertion order must correspond to the sequence order.

# ContextCapture Master

## Block

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- **Loop:** use only neighbor pairs within the given distance in a loop, advised for processing a single loop of photos if the Default mode has failed. The photo insertion order must correspond to the sequence order.

We recommend you to try the Default mode first.

### Component construction mode

The component construction algorithm can be changed to manage specific datasets:

- **One-pass:** advised for most datasets.
- **Multi-pass:** advised only if the *One-pass* mode fails to include a large proportion of photos in the main component. The *Multi-pass* mode takes significantly more computation time.

We recommend to try the *One-pass* mode first. This mode is only available when using the legacy engine.

### Blockwise color equalization

If enabled, an automatic color equalization will be computed for all input photographs during the aerotriangulation step. This equalization calculates the best way of ensuring consistency of appearance between all photographs, even in cases with great radiometric differences between images.

Note that this is a two-step process, needing both:

1. Activating the blockwise color equalization during the aerotriangulation.
2. Choosing "Blockwise" as the color equalization mode in the Reconstruction step.

For more details and an example result, please see the Reconstruction Processing Settings.

### Splats

If enabled, splats will be processed during aerotriangulation. Splats enrich the block representation in the 3D views. See also 3D view.

### Estimation methods

Estimation policy can be selected for the different block properties according to available data in the block.

Possible estimation behaviors for the different properties involved in the aerotriangulation are:

- **Compute:** estimate without using any input estimate,
- **Adjust:** estimate by adjusting the input estimate (according to the adjusted property, additional options can be proposed to manage the degree of freedom),
- **Adjust within tolerance:** estimate by adjusting the input estimate while staying close to the input estimate up to a user-defined tolerance,
- **Keep:** use the input estimate as is.

### *Optical properties estimation mode*

We recommend to try the *One-pass* mode first. The *Multi-pass* mode is useful when AT fails because the initial parameters are far from real values (e.g. unknown focal length or unknown large distortion). It takes significantly more computation time. If possible, prefer the faster and more robust method consisting in [Photos](#) (on page 48) estimated with some reference dataset.

### *Estimation groups*

Set this option to ignore the photogroup structure and estimate camera properties for each photo.

May be required for image acquisition with varying zoom/focal length, or with a multi-camera system (camera rig).

This option affects aerotriangulation accuracy if used unnecessarily.

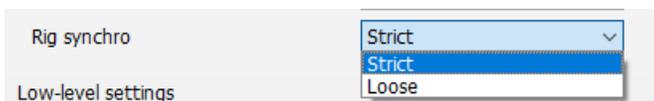
# ContextCapture Master

## Block

Using this option will result in an output block with one photogroup per photo.

### Rig Synchro

If a rig has been defined, an additional "Rig Synchro" entry is displayed. Use "Strict" if the synchronization between the different cameras of the rig is perfect, otherwise use "Loose".



### Low-level settings

Low-level settings can be set only through loaded presets. They can control directly all aerotriangulation processing settings.

Aerotriangulation presets may be provided by the technical support team to solve specific issues.

## Aerotriangulation processing

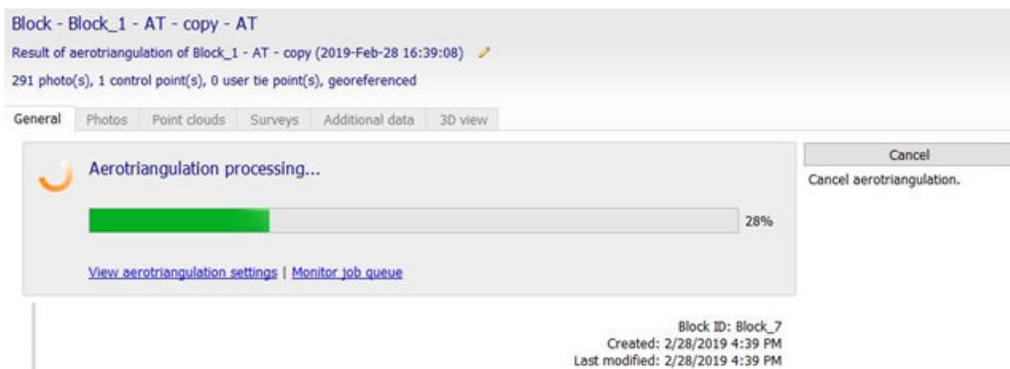
In the last page of the *Aerotriangulation definition* wizard, click on *Submit* to create the output block and submit the aerotriangulation job.



Create the output block and submit the aerotriangulation job.

Once the aerotriangulation is submitted, the output block is created waiting for the aerotriangulation result.

**Note:** The aerotriangulation is processed on Engine side. If there is no engine currently listening to the job queue, you must run an engine now or later to process the aerotriangulation.



During aerotriangulation, the block is being created: the interface is dedicated to monitoring the aerotriangulation job.

**Note:** You can continue working with ContextCapture Master or even close the interface while the aerotriangulation is pending or running: the job will remain in the queue and computation will be performed on the engine side.

During aerotriangulation, the number of lost photos is displayed. If too many photos are lost, you can cancel the aerotriangulation and remove the block to perform a new aerotriangulation with different settings.

If a potential issue is detected during the computation, an intermediate acquisition report is available. This reports helps to diagnose issues related to the input data by providing information on the disconnected components and lost photos.



In case of insufficient overlap or inappropriate input data, the aerotriangulation may fail.

### Aerotriangulation result

The aerotriangulation result is the output block: computed or estimated properties can be displayed through block properties, aerotriangulation report and acquisition report.



Figure 50: Example of block dashboard after an aerotriangulation

A successful aerotriangulation is supposed to compute positions and rotations for every photo. All photos must be included in the main component for future reconstruction steps.

Photos may be lost by the aerotriangulation in case of insufficient overlap or inappropriate input data. In such case, you can either:

- Go back to the input block, modify its properties if needed, and try a new aerotriangulation;
- Or use the output block as an intermediate result, and try a new aerotriangulation from this block to compute missing properties.

In some cases, even if all photos are successfully included in the main component of the output block, the latter can be further improved by a new aerotriangulation. For instance, new control points may be introduced in the output block and used in a new aerotriangulation to georeference the block.

### Result display

To overview the aerotriangulation result in 3D, use the 3D view tab of the output block. It allows you to visualize the position, rotation and field of view of photos, and the 3D position and color of tie points.

# ContextCapture Master

Block

Use the Quality Metrics available in the 3D view for advanced scene analysis.

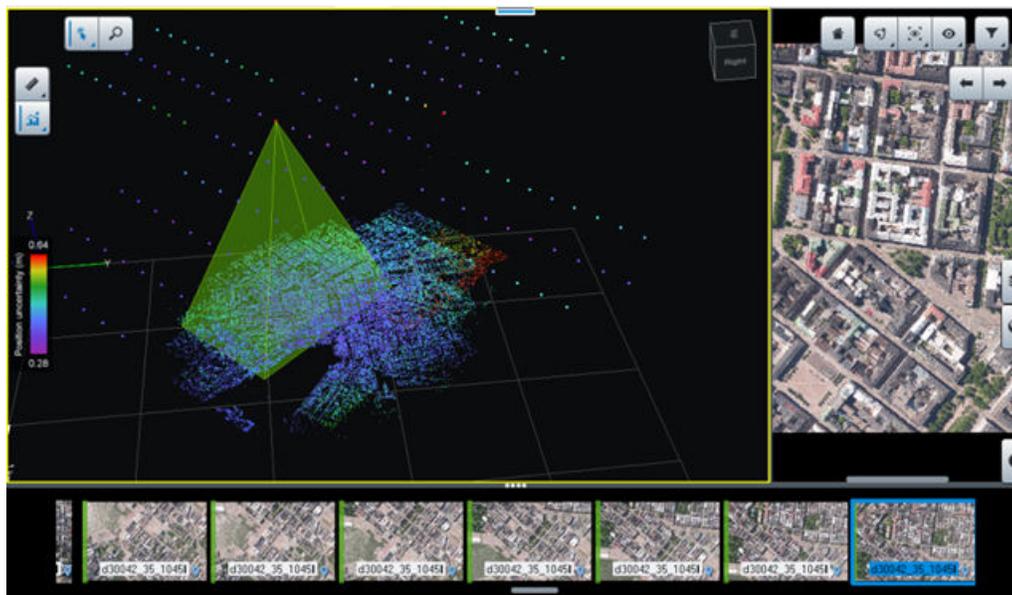


Figure 51: Example of aerotriangulation result displayed in the 3D view tab

Use the *Photos* tab to identify missing photos and to check estimated properties.

## Quality report

Click on the link *View quality report* to display aerotriangulation statistics.

The report displays the aerotriangulation main properties and statistics.

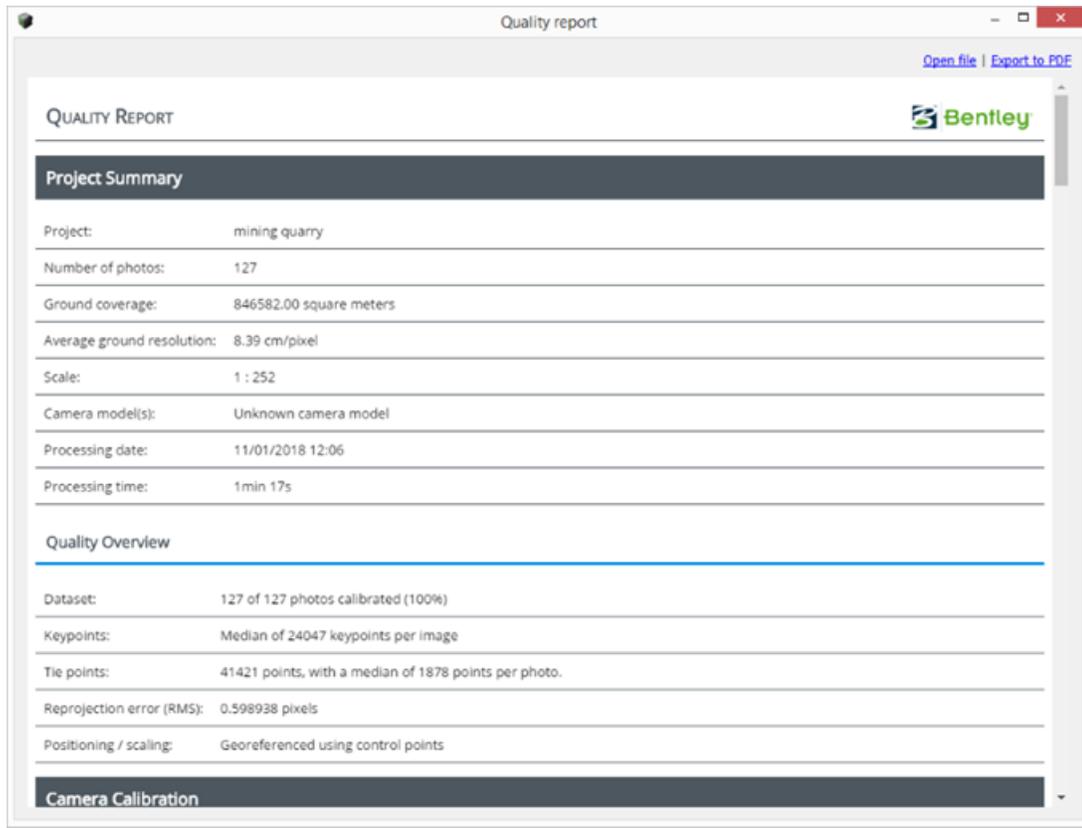


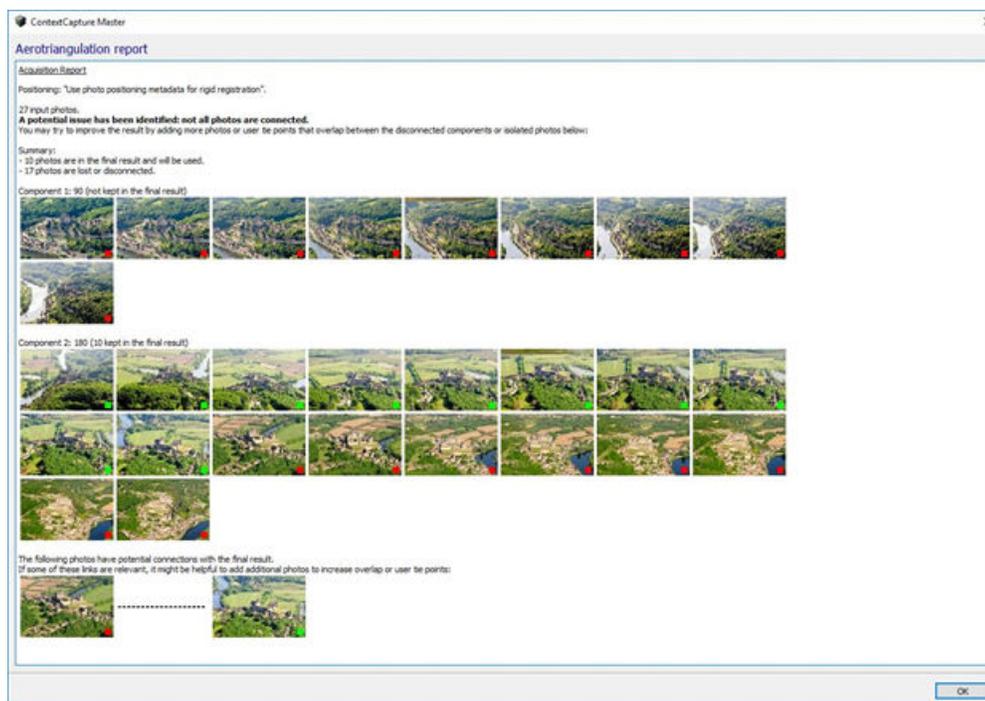
Figure 52: Example of aerotriangulation quality report

## Acquisition report

Click on the link View acquisition report to display information about the potential issues related to the input data. The report displays the several disconnected components identified by the aerotriangulation and give details on potential links between the lost photos and the result. It also provides details about the positioning mode requested and the actual mode used by the engine.

# ContextCapture Master

## Block



### Automatic tie points checking

Automatic tie points can be checked from the Automatic tie points navigator to perform quality control or to identify errors (see [Tie points](#) (on page 64)).

### Control points checking

When using control points, the [Control Points](#) (on page 59) can be used to perform quality control or to identify errors.

### Troubleshooting

In case of trouble with the aerotriangulation, the technical support team may ask you to export the aerotriangulation log file; you can export it from the block context menu in the project tree view: choose *Export / Export log file for technical support*.

**Note:** The log file is dedicated to technical support.

### Applications

The aerotriangulation result can be used in several ways:

- It is useful in itself to understand the spatial structure of the scene and of the photos,
- It can be exported to an XML or a KML file to use in third party software,
- It can be used in ContextCapture to perform 3D reconstruction.

## Process on the cloud

Project processing can run on the cloud with ContextCapture cloud processing service.

A ContextCapture Cloud Processing Console project is created from the block contents to allow cloud processing submission.

Learn more about cloud [ContextCapture cloud processing service](#) (on page 180).

## Import video frames

The Import video frames dialog allows you to extract frames from a video file and add them to the block.

To extract frames from a video, enter the input video file and select the import settings:

- Start time/end time: allows you to import only a section of the input video (by default all the video will be imported).
- Extract a photo every: sampling interval, in seconds. This defines the number of photos that will be extracted from the input video sequence.
- Photo output directory: directory where the extracted photos are created.

Please select the video sampling interval to ensure a correct overlap between photos.

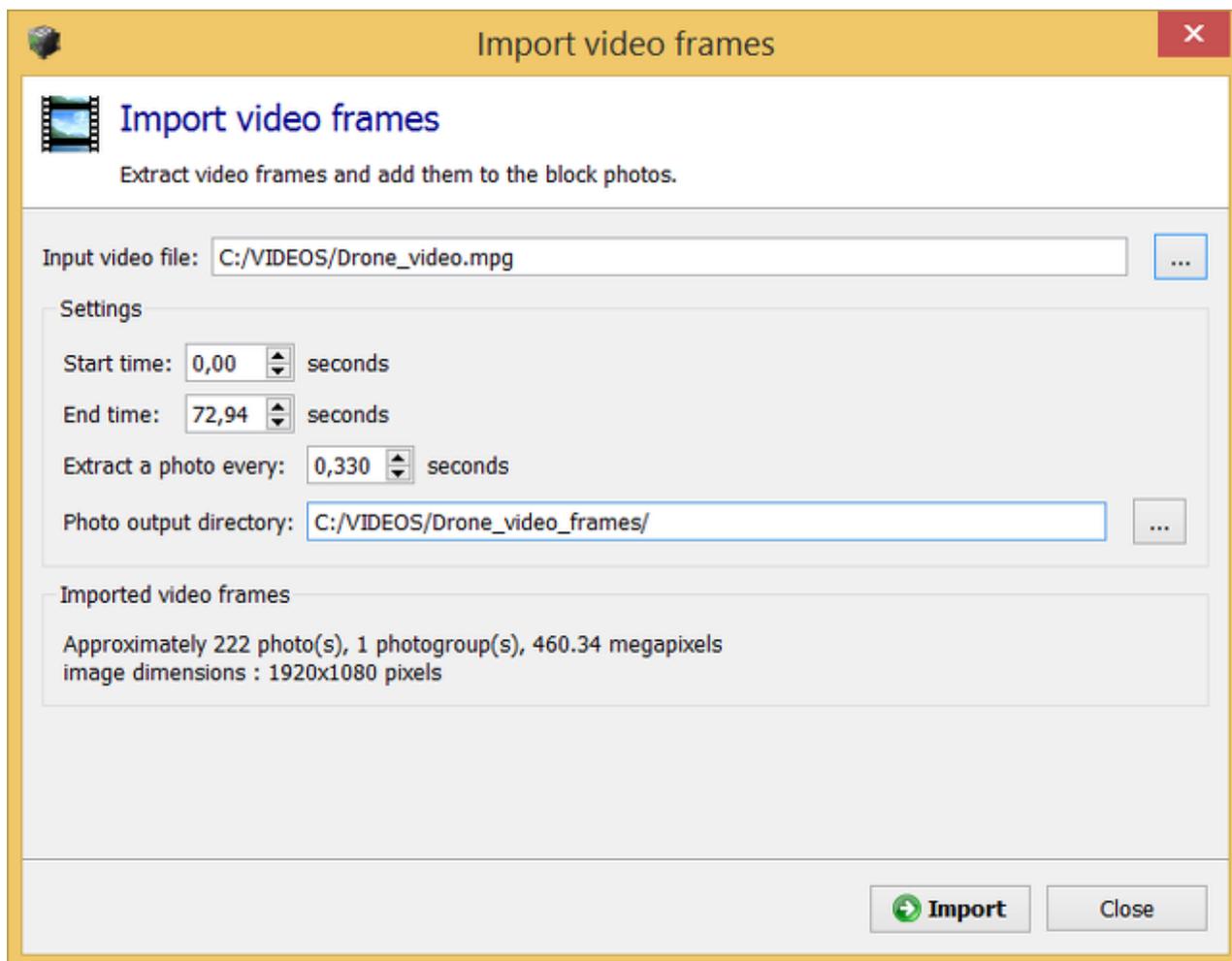


Figure 53: Import video frames dialog

⚠ Focal length variations are not supported.

All imported frames are added in one unique photogroup; ContextCapture assumes that the same camera model (with the same optical properties) is used during all the imported sequence. If the zoom varies during the video sequence, please use the start/end settings in our import to split the video in sections of constant zoom and to import each section separately.

Click on *Import* to extract and add the video frames.

Once imported, extracted photos can be inspected individually from the block's *Photos* page.

Frames imported from a video files have an unknown camera model. We recommend you to define the photogroup's main optical properties (sensor size, focal length and camera model type) before starting an aerotriangulation. One option for doing this is to search for a suitable camera model in the camera database ([Camera database](#) (on page 129)). See also [Photos](#) (on page 48).

In case no camera model in the database fits your camera, you can find your camera model attributes by using the self-calibration property of ContextCapture's aerotriangulation. For optimal results, we recommend you to use a 360° video of a highly textured and geometrically complex object. The camera parameters obtained after self-calibration can be stored in the camera database and reused for your more complex projects.

## Import photo positions

The Import photo positions dialog allows you to import photo positions and rotations from a text file.

Use this option to set image positions and/or rotations from third-party data.

Various kinds of text files are supported. The common condition for all formats is that each photo must be represented by a single line.

The imported data must include at least the photo references, and the 3 coordinates for the photo positions. Rotations are optional.

*<_____Photo_File_____><_____Easting____><_____Northing____><_____Height____><_____	_____	_____	_____	_____
_____Omega_____><_____Phi_____><_____Kappa_____>	_____	_____	_____	_____
f:\project\images\4655.tif	47268.5080	-517764.1880	1514.7160	
-0.2352	0.2168	-2.3779		
f:\project\images\4656.tif	46434.1570	-517745.9920		
1513.0090	0.0662	1.1163	-2.2503	
f:\project\images\4657.tif	45618.8710	-517748.2010		
1516.4190	0.0227	0.6976	-1.2857	
f:\project\images\4658.tif	44815.0070	-517756.2330		
1520.3310	0.6212	0.1720	-0.6776	
f:\project\images\4659.tif	43971.6950	-517762.4530		
1519.1290	0.3699	0.2398	-1.9075	
f:\project\images\4660.tif	43116.7510	-517767.1580	1518.0000	
-0.4866	-0.4373	-2.8745		
f:\project\images\4661.tif	42266.8970	-517754.3210	1519.9090	
-0.3243	0.8787	-2.6415		
f:\project\images\4662.tif	41407.3450	-517763.1880		
1525.5080	0.0320	0.2612	0.0047	
f:\project\images\4663.tif	40520.2080	-517783.6610		
1523.6580	0.1627	0.7922	-2.7976	

*Example of text file with positions and rotations*

To import an entire block, with camera models, control points, etc., you can use the XML or Excel formats. See also [Import blocks](#) (on page 108).

## Input file

*Enter the input text file*

To start importing the third-party data, choose the input text file.

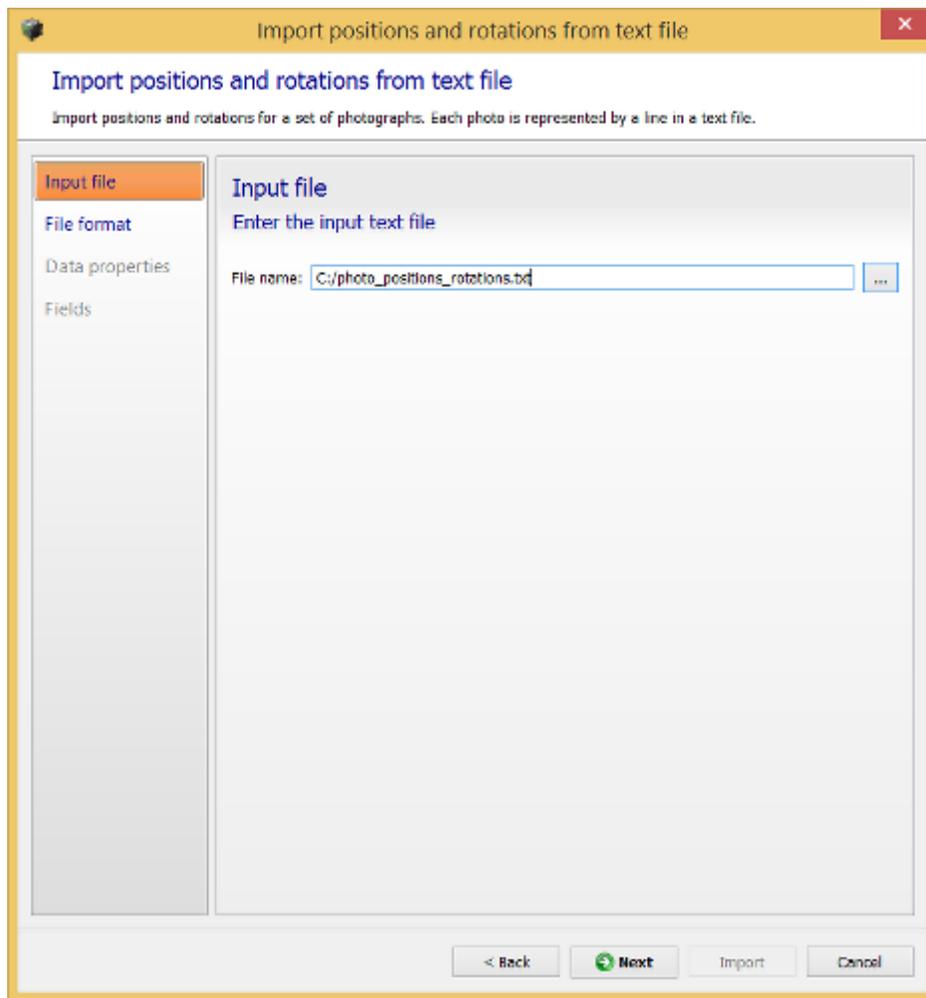


Figure 54: Page Input file

## File format

*Define how the input file must be read*

Once the input file loaded, ContextCapture tries to make a first guess on the content of this file.

You can adjust the import parameters, so that each column in the Data preview table contains meaningful information:

- Number of lines to ignore at the beginning of the file: defines the length of the file header, and ignores it during import.
- Delimiters: defines the column separators. Several characters can be specified.

The option *Combine consecutive delimiters* can be required, for instance when sequences of white spaces are used as delimiter.

- Decimal separator: dot (123.456) or comma (123,456).

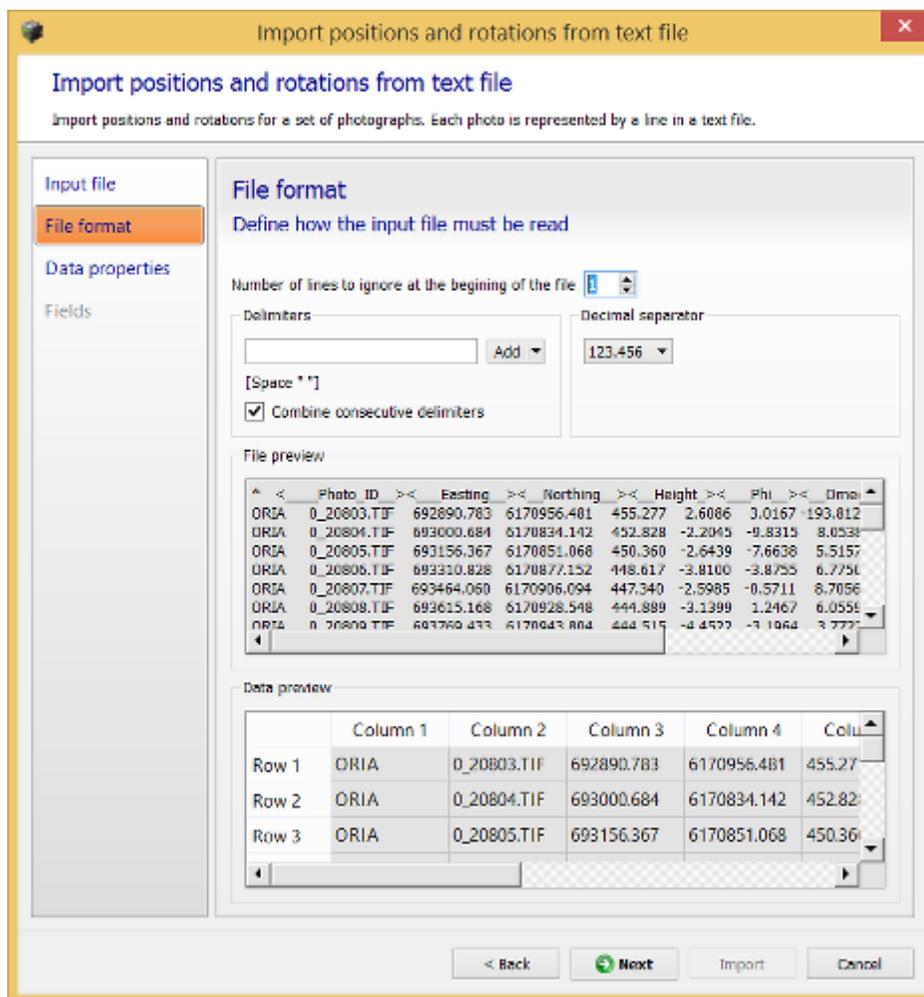


Figure 55: Page File format

**Note:** Empty lines are ignored.

## Data properties

### Define the imported data

Define the spatial reference system of imported positions and optional rotation parameters.

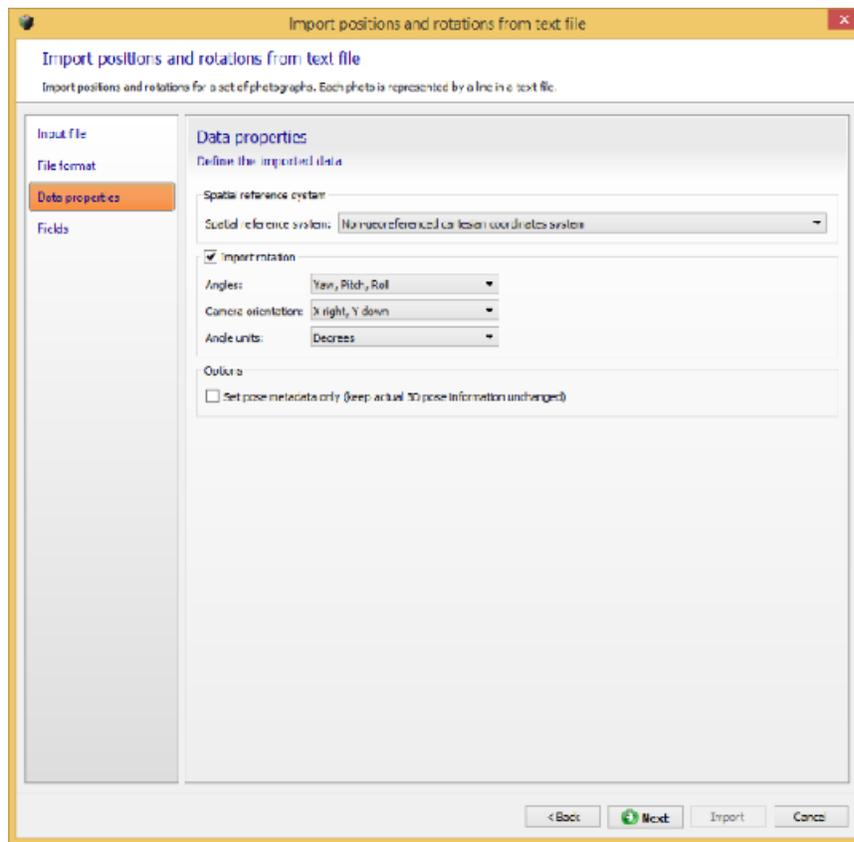
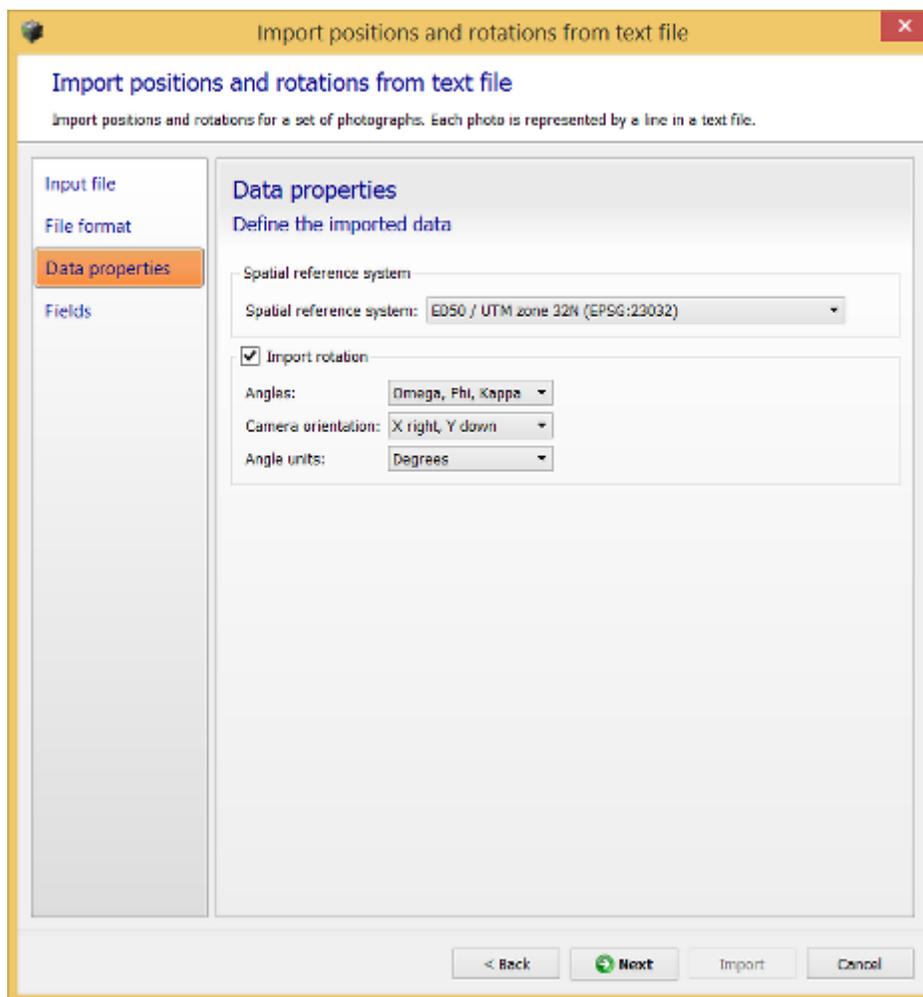


Figure 56: Page Data properties



## Spatial Reference System

*Specify the coordinate system of the imported data*

For data that does not have georeferenced positions, choose Local coordinate system (with known or arbitrary unit).

## Input File Rotation

*Define optional rotation properties.*

Check this option and choose the rotation properties if the input file contains photo rotations.

Rotation properties are:

- Angles: angles types: *Omega, Phi, Kappa, Yaw, Pitch, Roll or Heading, Pitch, Roll (deprecated)*.
- Rotations given in a matrix form are not supported here.
- Camera orientation: specification of the xy-axis of the camera sensor for pose rotation.

Possible values are: *X right Y down* (default), *X right Y up* (more frequent in photogrammetry), *X left Y down*, *X left Y up*, *X down Y right*, *X down Y left*, *X up Y right*, *X up Y left*.

# ContextCapture Master

Block

- Angle units: *Degrees* or *Radians*.

## Options

Additional data properties options.

- Set pose metadata only: Keep actual 3D pose information unchanged. This option can be used to ensure that the imported positions and rotations will only affect the photos pose metadata property and will conserve the current pose information if any. The default behavior is to update both the photos pose property and pose metadata information with the imported positions and rotations.

## Fields

Specify columns corresponding to the imported data

You must associate each input column with its respective role.

The list of possible roles adapts to the input data type. For example, if the data does not contain rotations, no angles will be proposed as a possible data type.

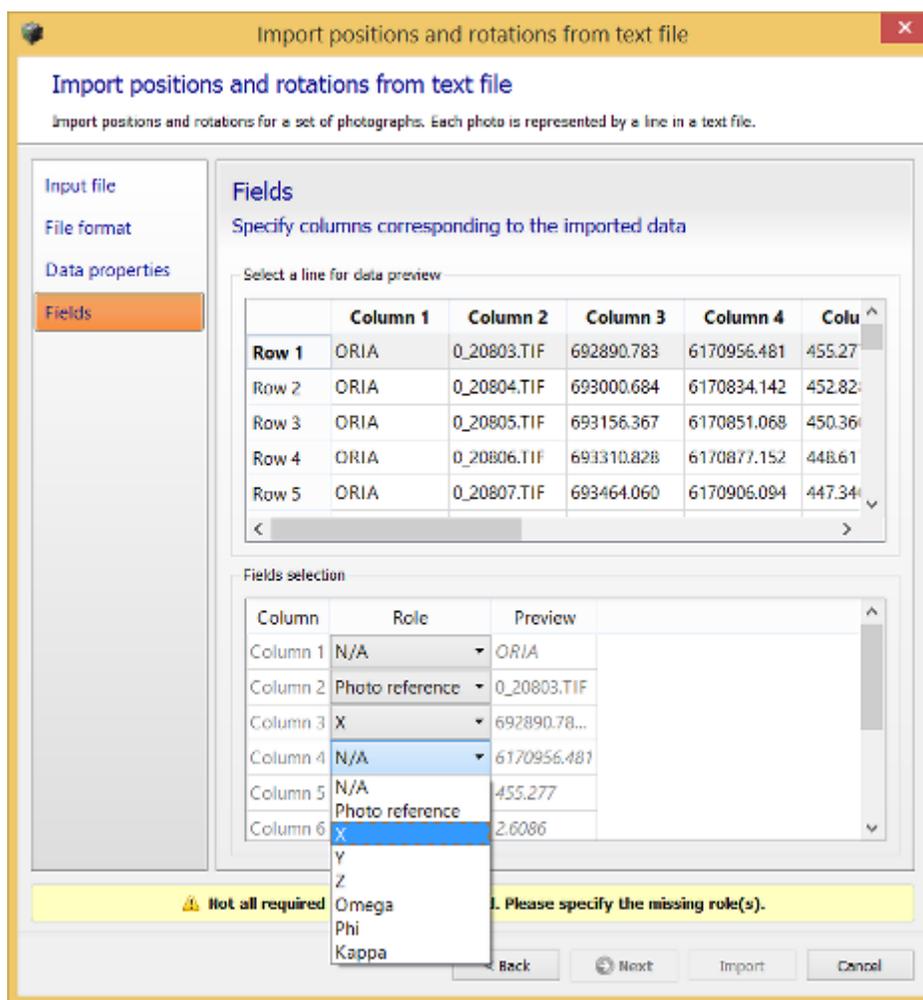


Figure 57: Page fields

# ContextCapture Master

## Block

---

Once each data type is associated with a unique column, you can proceed to the import. ContextCapture will then try to match each line to a photo in the block, and apply the photo details to the matched photo. If unsuccessful, an error or a warning message will alert you of the problem, and you can choose to cancel the operation.

**Note:** The "*Import positions and rotations*" method can match a photo of the block with its corresponding line of text only if the line contains the full photo name.

For example, for a photo named `img_0.tif`, the corresponding photo reference needs to be either `img_0`, or `img_0.ext`, where `ext` is an arbitrary extension.

## Import blocks

Import complete or partial blocks definition from files or from a server.

**Note:** Importing complete block definition is the only way to handle a very large number of photos with ContextCapture .

The following sources are supported:

- BlocksExchange XML/XMLZ format: an open exchange format specified by *Bentley* to import/export block definition.  
[BlocksExchange XML/XMLZ format](#) (on page 119).
  - MS Excel XLS format: a block definition based on Microsoft Excel XLS file.  
[MS Excel block definition](#) (on page 127)
  - ContextCapture Orientations from ProjectWise ContextShare portal.
-  An ATEExport XML export file cannot be re-imported in ContextCapture .

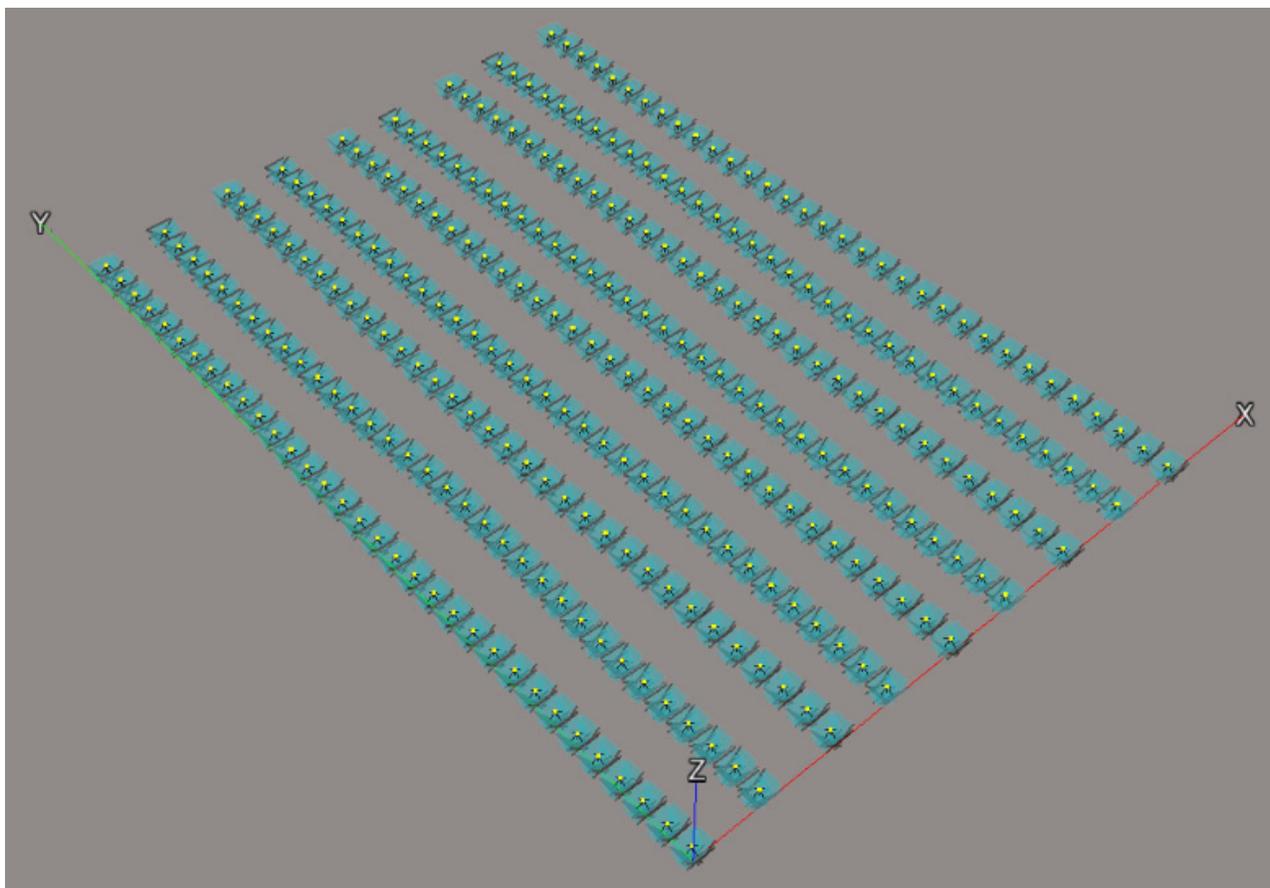


Figure 58: Example of imported block

## Import surveys data

Import control points, user tie points and positioning constraints in the block from Surveys Data XML format.

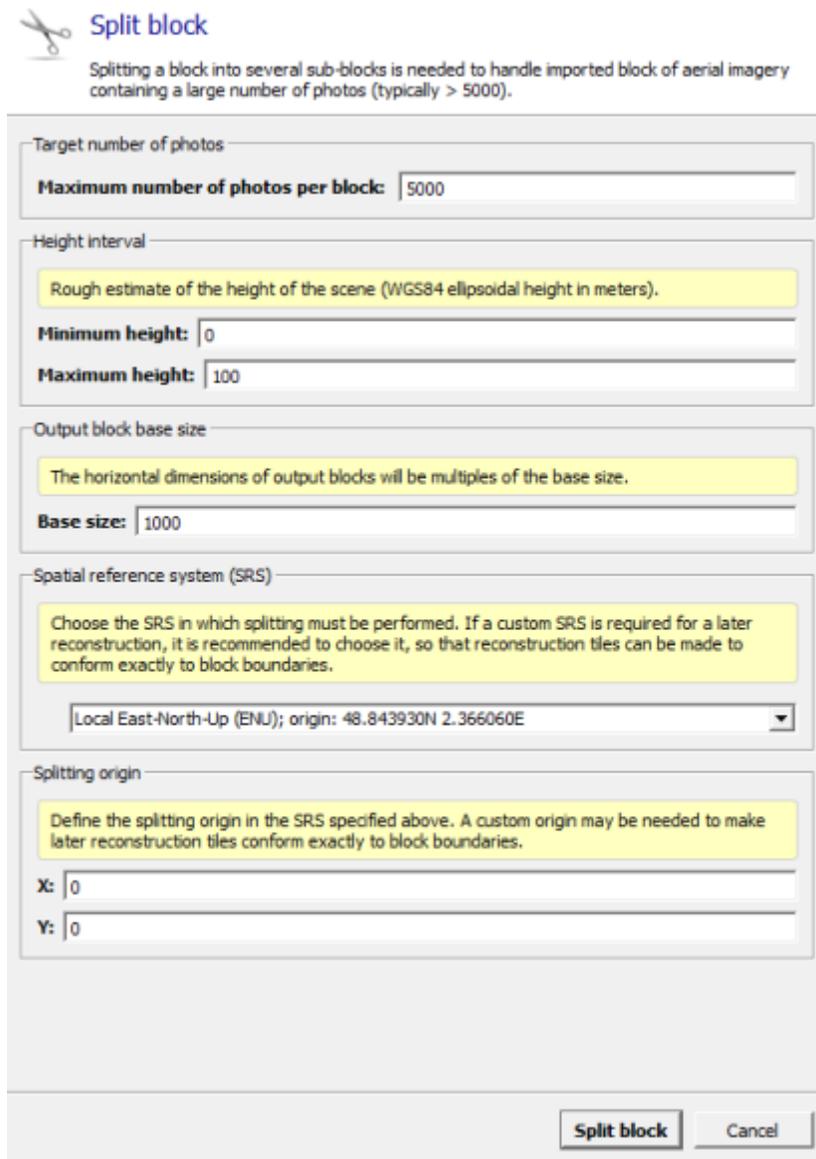
See also: Export surveys data.

## Split block

Splitting a block into several sub-blocks is needed to handle imported block of aerial imagery containing a large number of photos (typically > 5000).

# ContextCapture Master

## Block



**Split block**

Splitting a block into several sub-blocks is needed to handle imported block of aerial imagery containing a large number of photos (typically > 5000).

Target number of photos

**Maximum number of photos per block:**

Height interval

Rough estimate of the height of the scene (WGS84 ellipsoidal height in meters).

**Minimum height:**

**Maximum height:**

Output block base size

The horizontal dimensions of output blocks will be multiples of the base size.

**Base size:**

Spatial reference system (SRS)

Choose the SRS in which splitting must be performed. If a custom SRS is required for a later reconstruction, it is recommended to choose it, so that reconstruction tiles can be made to conform exactly to block boundaries.

Splitting origin

Define the splitting origin in the SRS specified above. A custom origin may be needed to make later reconstruction tiles conform exactly to block boundaries.

**X:**

**Y:**

**Split block**

Figure 59: Split block dialog

### Split settings

 You must not specify height above sea level. For more information, please refer to [Useful concepts](#) (on page 15).

### Target number of photos

Enter the maximum number of photos you want for output blocks.

### Height interval

Enter the rough estimate of the scene ellipsoidal height interval.

### Output block base size

Enter the base size of output blocks. Actual dimensions of output blocks will be multiple of this base size.

For instance:

*Base size: 500*

*The actual output block size may be: 500, 1000, 1500... depending on the scene contents and other split settings.*

### Spatial reference system (SRS)

Choose the SRS in which splitting must be performed.

By default, use a Local East-North-Up system with an origin set at the centroid of input block's photo positions.

If a custom SRS is required for a later reconstruction, it is recommended to choose it, so that reconstruction tiles can be made to conform exactly to block boundaries.

### Splitting origin

Define the splitting origin in the specified SRS.

A custom origin may be needed to make later reconstruction tiles conform exactly to block boundaries.

### Split processing

Click on *Split block* to start the split processing.

Split divides the aerial block into several parts according to a regular 2D grid.

To perform a reconstruction of all parts, you must take care on further reconstruction spatial framework settings in order to get compatible tiles and coordinate system.

When defining a reconstruction for one block part, please define the spatial framework as follows:

- Use the same SRS to define all reconstructions spatial framework.
- Use regular planar grid as tiling mode
- Use a tile size that divides the block size.
- Use (0 ; 0), or multiples of the block size, as custom tiling origin coordinates.
- Use the region of interest corresponding to the block part.

Adequate reconstruction spatial framework settings are reminded in the split report and recalled in the description of each block part.

**Note:** Once split, the parent block may be unloaded to save memory and loading/saving time (right click > Unload). See also [Load/unload blocks](#) (on page 117).

The split process also generates a KML file useful to get an overview of computed sub-block regions.

The KML file is accessible in the project folder: *myBlock - sub-block regions.kml*.

# ContextCapture Master

Block

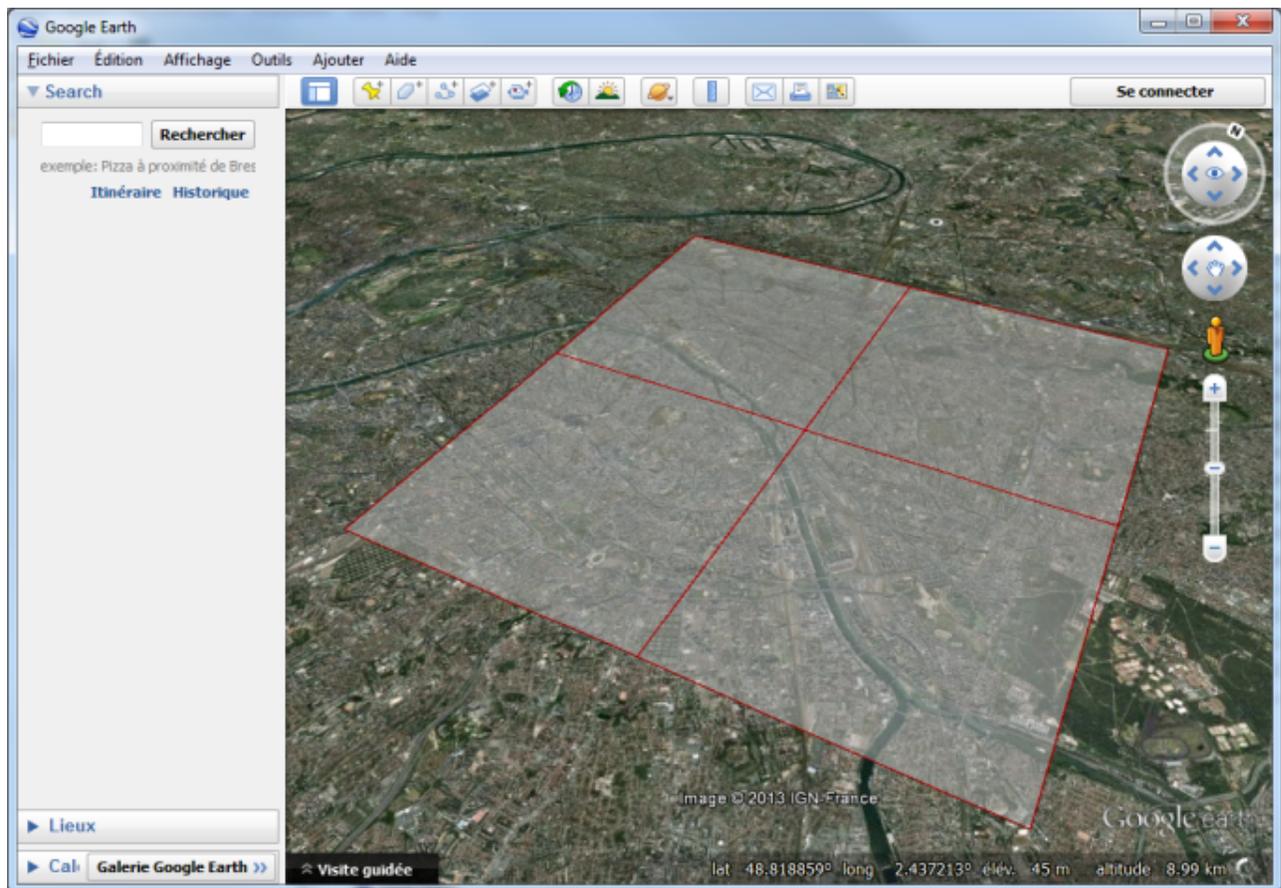


Figure 60: Sub-block regions overview in Google Earth

## Extract block

Extract a sub-block which covers a given region.

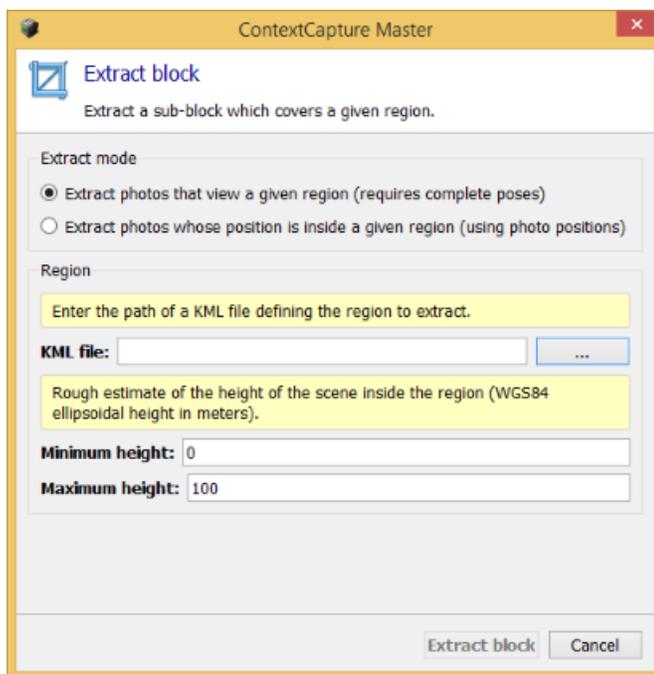


Figure 61: Extract block dialog

## Extract settings

Two extraction modes are available:

- Extract photos that view a given region (requires complete poses).
- Extract photos whose position is inside a given region (using photo positions).

### Region

Enter the required region parameters according to the selected extraction mode:

- KML file

Enter the path of a KML file defining the region to extract.

You can use any GIS tool or *Google Earth* to create a KML file.

- Height interval

Enter the rough estimate of the scene ellipsoidal height interval inside the region.

⚠ You must not specify height above sea level. For more information, please refer to [Useful concepts](#) (on page 15).

- Margin (in meters)

Enter a margin if you want to extend the selected region.

## Extract processing

Click on *Extract block* to start the extract processing.

Extract create a new sub-block limited to the 2D region defined by the KML file.

# ContextCapture Master

Block

**Note:** Once extracted, the parent block may be unloaded to save memory and loading/saving time (right click > Unload).

See also [Load/unload blocks](#) (on page 117).

## Export

### Export block

Menu *Block > Export > Export block*

Export block properties in various formats.

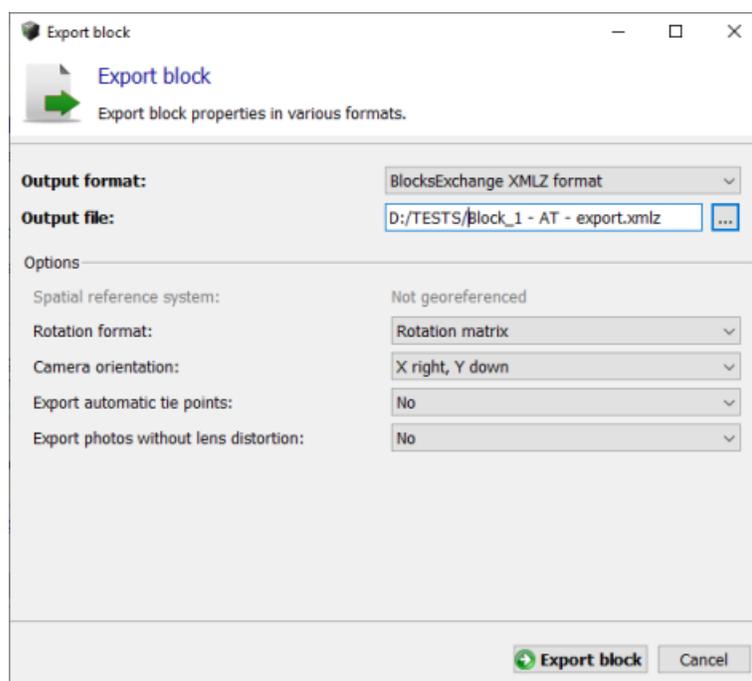


Figure 62: The export block dialog

Select the output format, output file and options; and click on Export block to create the XML file.

The following output formats are supported:

- BlocksExchange XML/XMLZ format: an open exchange format specified by Bentley to import/export block definition. [BlocksExchange XML/XMLZ format](#) (on page 119).  
XMLZ format is an extension of XML format adding file compression for convenience (zip).
- ATEExport XML format: Basic export of block main properties in XML format. [ATEExport XML format](#) (on page 128).

**⚠** The ATEExport XML format is a simplified format made for exporting to 3rd party software only. You must use the BlocksExchange XML format if you want to later re-import blocks in ContextCapture.

Google Earth KML: Export photo positions and some other properties to a KML file.

# ContextCapture Master

## Block

The exported KML file is suited to visualize the photo positions in a standard GIS tool or in Google Earth.

- TREND-ONE XML: custom block format dedicated to TREND-ONE.

According to the selected format and to block properties, following options are available:

- Spatial reference system: select the coordinate system used to write 3D positions and rotations (only for a georeferenced block).
- Rotation format: select how rotations are written, Rotation matrix or Omega, Phi, Kappa angles (only for blocks with known rotations).
- Camera orientation: select the axis convention for rotations (only for blocks with known rotations).
- Include automatic tie points: include automatic tie points in the export.

⚠ Exporting automatic tie points may produce heavy XML files.

- Export photos without lens distortion: photos are undistorted according to the block's distortion data and exported to JPG files in a sub-directory.

⚠ Exporting photos without lens distortion may produce heavy files.

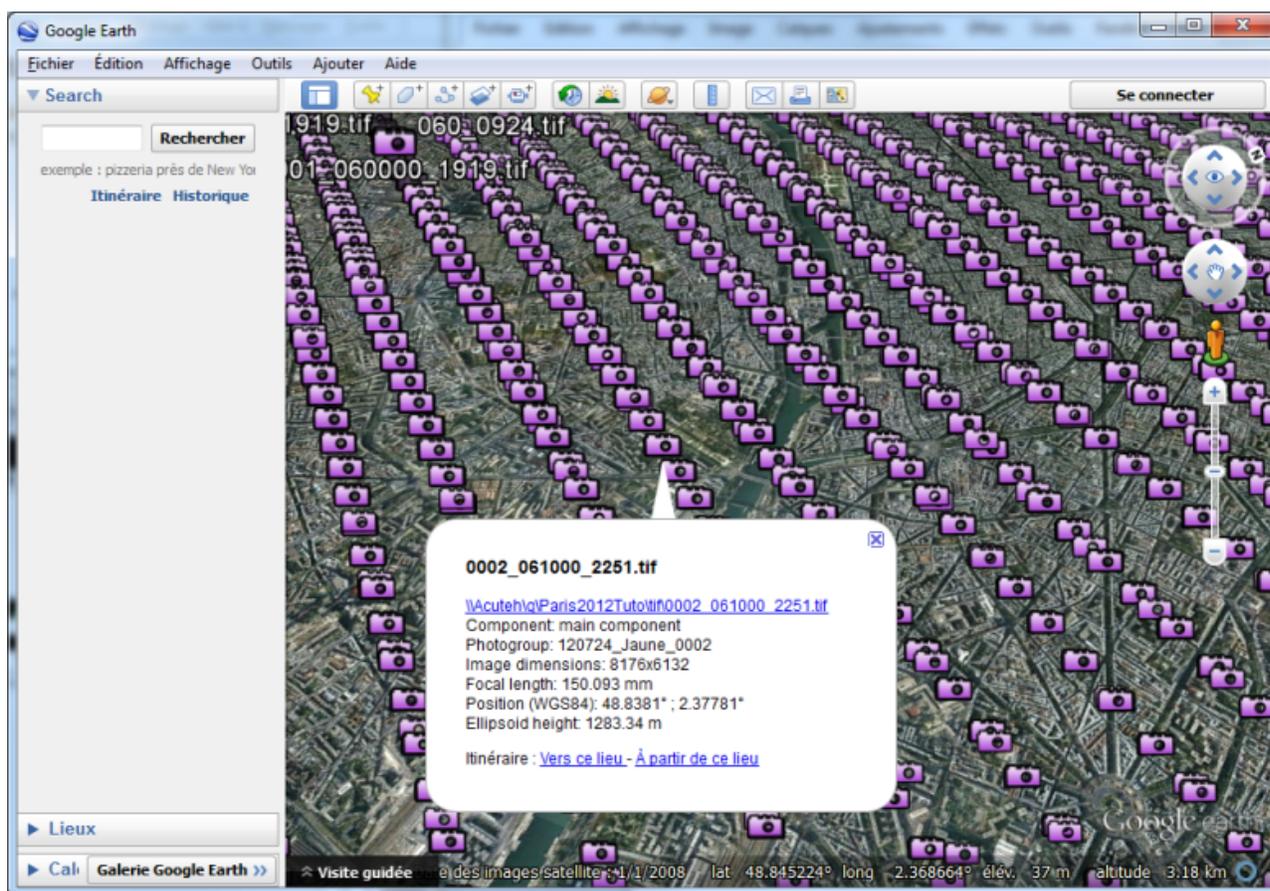


Figure 63: Example of block KML export displayed in GoogleEarth

## Export surveys

Menu Block > Export > Export surveys

# ContextCapture Master

Block

Export control points, user tie points and constraints to various formats.

- ContextCapture Surveys File: XML format is suited for exchanging surveys between blocks or projects (including control points and user tie points with measurements and positioning constraints).
- Text File [Name X Y Z]
- KML file (for georeferenced blocks only): format suited to visualize the photo positions in a standard GIS tool or in Google Earth.

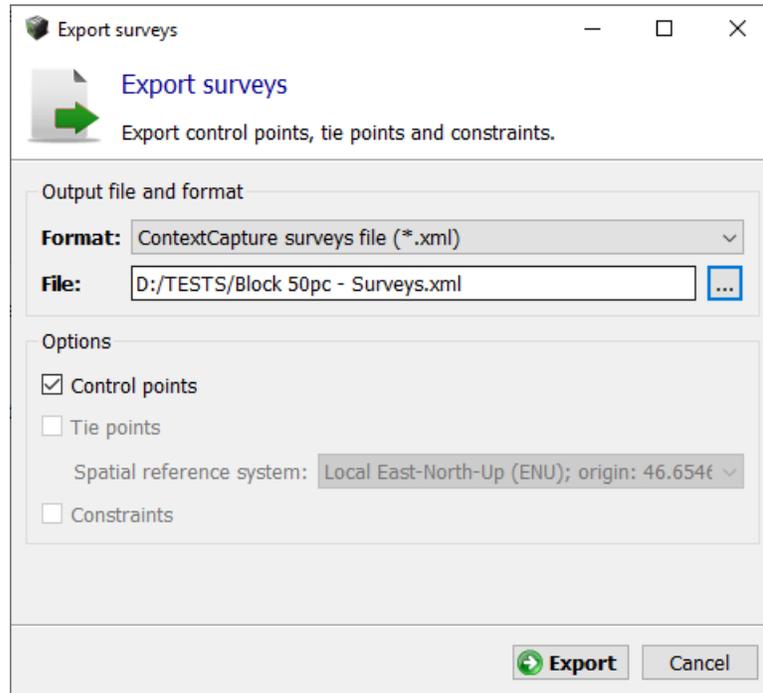


Figure 64: Export surveys dialog

## Export to Orbit 3DM

Create a Mapping Run for Orbit 3DM from block imagery and productions.

# ContextCapture Master

Block

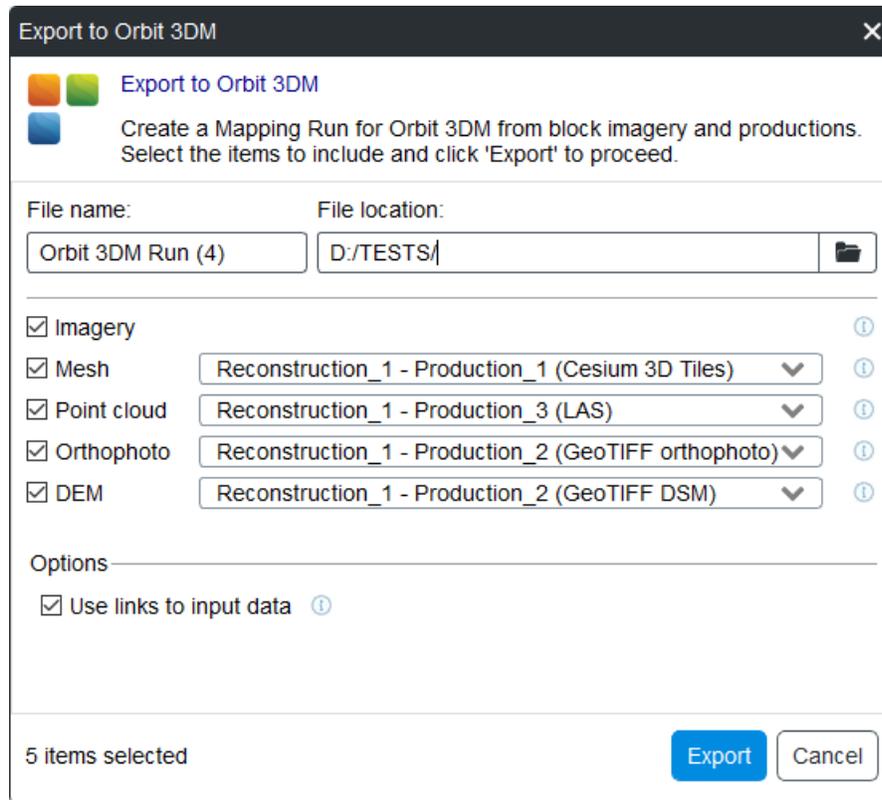


Figure 65: Export to Orbit 3DM dialog

Select the items to include and click 'Export' to proceed.

## Share on ProjectWise ContextShare

ProjectWise ContextShare is the Bentley platform to publish, manage and share reality data. You need to be signed up with your Bentley CONNECT account.

A ContextCapture block is composed of three types of data:

- Image collection: set of input image files for this block.
- Scan collection: set of point clouds for this block.
- Orientation: defining positions, rotations and optical properties of the images part of the image collection.

To learn more about sharing on ProjectWise ContextShare, see Web publishing, [Share on ProjectWise ContextShare](#) (on page 181).

## Load/unload blocks

*Load/unload blocks from the current project.*

You can make blocks temporarily unavailable within a project, and later restore them.

*Unload block allows to save memory and to reduce project loading time.*

# ContextCapture Master

## Block

---

### To unload blocks from a project

In the project tree view, select a block that you want to unload from the current project.

In the block context menu (right click on the block), choose *Unload*.

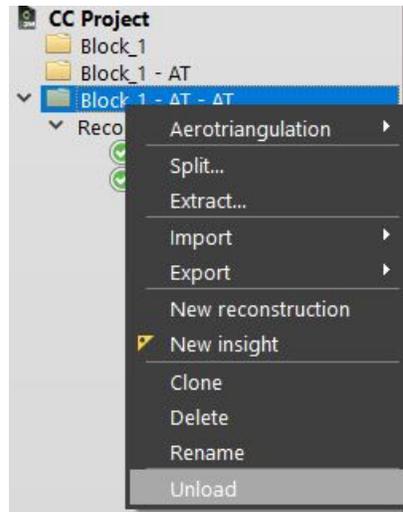


Figure 66: Unload block from block context menu

The block is now displayed as unloaded, and its icon in the project tree view is grayed out.

### To load blocks into a project

In the project tree view, select a block that is unloaded.

In the block context menu, choose *Load*.

The block is now available for use in the current project.

## Merge blocks

Merge a selection of blocks into one new block.

Define the input blocks by performing a multi-selection in the project tree view using Shift or Ctrl keys.

From the selection context menu (right click), call Merge blocks.

You can merge several blocks only if they use a compatible positioning level (for example, if all selected blocks are georeferenced).

## ContextCapture Master

Block

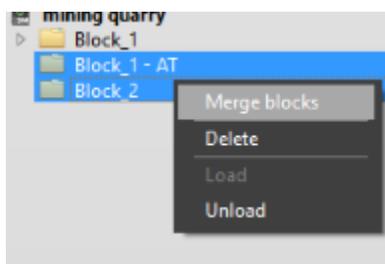


Figure 67: Merging a selection of blocks

## BlocksExchange XML/XMLZ format

The BlocksExchange XML format is an open exchange format specified by Bentley to import/export blocks definition in ContextCapture Master.

The XML file can include properties of one or several blocks.

XMLZ format is an extension of XML format adding file compression for convenience (zip).

### Format specifications

```
<?xml version="1.0" encoding="utf-8"?>
<BlocksExchange version="2.1">
  <!-- Definition of one or several useful spatial reference systems (SRS). -->
  <!-- Here, we need the French Lambert 93. -->
  <SpatialReferenceSystems>
    <SRS>
      <!-- In the sequel, the SRS is referred to by this ID. -->
      <Id>0</Id>
      <!-- User-friendly SRS name. -->
      <Name>Lambert 93</Name>
      <!-- The spatial reference system definition can be either a Well Known
Text
definition (e.g. WGS84), "EPSG: ", a PROJ.4 definition, or the path to a file
containing such a definition. -->
      <Definition>EPSG:2154</Definition>
    </SRS>
  </SpatialReferenceSystems>
  <!-- Optional: a path to prefix image paths when they are not absolute
(default: use the directory of the exchange file). -->
  <BaseImagePath>D:\data\Paris2012sample\Images</BaseImagePath>
  <!-- Block definition. A single file can define several blocks. -->
  <Block>
    <!-- Block name and description are optional. -->
    <Name>Paris2012</Name>
    <Description>Small sample of the Paris 2012 dataset</Description>
    <!-- The type of block is optional. Supported types are: Aerial, Nadir and
Orbit. -->
    <Type>Aerial</Type>
    <!-- Photo downsampling rate can be optionally provided with
<PhotoDownsamplingRate> tag -->
    <!-- Minmum and maximum viewing distance can be optionally provided with
<MinimumViewingDistance> and <MaximumViewingDistance> tags -->
    <!-- ID of the base SRS used in the block. By default, the spatial reference
system is assumed to be a local Cartesian coordinate system. -->
```

## ContextCapture Master

Block

```
<SRSId>0</SRSId>
<Photogroups>
  <!-- All photos taken using the same physical camera, with identical focal
length and dimensions must be gathered in a photogroup. -->
  <Photogroup>
    <!-- Optionally, a different spatial reference system can be specified
for
each photogroup with the <SRSId> tag. By default, the SRS of the block is assumed.
-->
    <!-- Optionally, a name with the <Name> tag, and a description with a
<Description> tag. -->
    <Name>UCX</Name>
    <!-- Image dimensions, in pixels. -->
    <ImageDimensions>
      <Width>9420</Width>
      <Height>14430</Height>
    </ImageDimensions>
    <!-- Optional camera model type Perspective or Fisheye (Perspective
type is used if this tag is unspecified). -->
    <CameraModelType>Perspective</CameraModelType>
    <!-- Optional camera model band Visible or Thermal (Visible type is
used if this tag is unspecified). -->
    <CameraModelBand>Visible</CameraModelBand>
    <!-- Sensor's largest dimension, in millimeters. -->
    <!-- Sensor's pixel size, in millimeters, can be substituted for this
field.
-->
    <!-- For this dataset, it would be: -->
    <!-- <PixelSize>0.0072</PixelSize> -->
    <SensorSize>103.896</SensorSize>
    <!-- Focal length, in millimeters. This can be either the nominal
specification or a closer estimate. -->
    <FocalLength>100.735601903992</FocalLength>
    <!-- Optionally, focal length, in pixels. Can replace FocalLength and
SensorSize data. -->
    <!-- For this dataset, it would be: -->
    <!-- <FocalLengthPixels>13991.05582</FocalLengthPixels> -->
    <!-- Optionally, specification of the xy-axis of the camera sensor for
pose rotation and for any position given in millimeter (i.e. <PrincipalPoint> and
<Measurement> when using <xmm> and <ymm>) -->
    <!-- Possible values: XRightYDown (default), XRightYUp (more frequent
in photogrammetry), XLeftYDown, XLeftYUp, XDownYRight, XDownYLeft, XUpYRight,
XUpYLeft -->
    <CameraOrientation>XRightYDown</CameraOrientation>
    <!-- Principal point, with respect to the sensor center. This field is
optional: by default, the sensor center is used as an initial estimate of the
principal point. -->
    <PrincipalPoint>
      <!-- 2D image position of the principal point, in pixels. The
origin
is the center of the upper-left image pixel, the x-axis is oriented to the
right side of the image, and the y-axis is oriented to the bottom of the image. -->
      <x>4683.755692</x>
      <y>7223.0141002</y>
      <!-- Alternatively, a 2D position with respect to the sensor
center can be specified, in millimeters. In this case, the xy-axis are oriented
according to CameraOrientation. -->
      <!-- For this dataset, it would be: -->
```

## ContextCapture Master

Block

```
        <!-- <xmm>-0.1853590176</xmm> -->
        <!-- <yymm>0.06130152144</yymm> -->
    </PrincipalPoint>
    <!-- Lens distortion coefficients. This field is optional: by
default,
no distortion is assumed as an initial estimate. -->
    <!-- Distortion coefficients correspond to the classical Brown's
distortion model, as described in http://en.wikipedia.org/wiki/Distortion\_\(optics\)
. -->
    <Distortion>
        <K1>-0.0010041516639</K1>
        <K2>0.0056007056563</K2>
        <K3>-0.009874171117100001</K3>
        <P1>0</P1>
        <P2>0</P2>
    </Distortion>
    <!-- Fisheye focal matrix used only for the camera model type Fisheye.
-->
    <FisheyeFocalMatrix>
        <M_00>1960</M_00>
        <M_01>0</M_01>
        <M_10>0</M_10>
        <M_11>1960</M_11>
    </FisheyeFocalMatrix>
    <!-- Fisheye distortion coefficients used only for the camera model
type
Fisheye. -->
    <FisheyeDistortion>
        <P0>0</K1>
        <P1>1</K2>
        <P2>0</K3>
        <P3>0</P1>
        <P4>0</P2>
    </FisheyeDistortion>
    <Photo>
        <!-- The ID of a photograph must be unique over the whole block
(in other
words, even across other photogroups). -->
        <Id>146</Id>
        <!-- Path of the image. If not absolute, it is considered to be
relative to
BaseImagePath if defined, or otherwise to the directory of the exchange file. -->
        <ImagePath>071_2810.jpg</ImagePath>
        <!-- Optional path of the image mask. If not absolute, it is
considered to be relative to BaseImagePath if defined, or otherwise to the
directory of the exchange file. -->
        <!-- <MaskPath>071_2810_msk.jpg</MaskPath> -->
        <!-- Exterior orientation of the camera, as estimated by
navigation
devices or aerotriangulation. This field is optional. -->
        <!-- Optional component Id: 1 is the main component (default), 0
is no
component. Photos with incomplete pose cannot belong to the main component -->
        <!-- <Component>1</Component> -->
        <Pose>
            <!-- 3D rotation of the camera in the spatial reference system
defined above. -->
            <!-- It defines the rotation matrix transforming world
```

## ContextCapture Master

Block

```
coordinates
(in the specified SRS) into camera coordinates (with axes defined by the
CameraOrientation of the photogroup). -->
    <!-- The rotation is optional: the pose can be limited to the
3D position
of the camera center (e.g. when GPS position only is available). -->
    <Rotation>
        <!-- It can be specified in one of the four
representations below: -->
            <!-- 1. A 3x3 matrix, using the <M_ij> tags, where M_ij
denotes the
coefficient of the (i+1)th row and the (j+1)th column of the rotation matrix. -->
            <M_00>-0.9999982912233401</M_00>
            <M_01>-0.001636319085375301</M_01>
            <M_02>-0.0008602425863163225</M_02>
            <M_10>-0.001631068695467463</M_10>
            <M_11>0.9999802528616577</M_11>
            <M_12>-0.00606906089589293</M_12>
            <M_20>0.0008701565192966738</M_20>
            <M_21>-0.006067647409696231</M_21>
            <M_22>-0.9999812130648239</M_22>
            <!-- 2. Omega/Phi/Kappa angles, in degrees, using the
<Omega>, <Phi>,
<Kappa> tags. Please refer to the formula in the camera model document. -->
            <!-- For this dataset, it would be: -->
            <!-- <Omega>179.6523471469934</Omega> -->
            <!-- <Phi>0.04985630236313049</Phi> -->
            <!-- <Kappa>179.9065465708369</Kappa> -->
            <!-- 3. Heading/Pitch/Roll angles, in degrees using the
<Heading>,
<Pitch>, <Roll> tags. Please refer to the formula in the camera model document. -->
            <!-- 4. Yaw/Pitch/Roll angles, in degrees using the <Yaw>, ,Pitch>,
<Roll> tags. Please refer to the formula in the camera model document. --
>
        </Rotation>
        <!-- 3D position of the camera center in the spatial reference
system
defined above. -->
        <!-- Depending on the SRS, x/y may stand either for longitude/
latitude,
for map projection coordinates, or for something else. -->
        <!-- Depending on the SRS, z may stand either for a geoid
height, for
an orthometric height, or for something else. -->
        <Center>
            <x>651999.7159189156</x>
            <y>6863073.633923346</y>
            <z>1318.897690166719</z>
        </Center>
        </Pose>
        <!-- Optional depth information can be provided with <NearDepth>,
<MedianDepth>, and <FarDepth> tags -->
        <!-- Optional Exif data (each exif data property is optional)
--><!--
        <ExifData>
            <ImageDimensions>
                <Width>4000</Width>
                <Height>3000</Height>
```

## ContextCapture Master

Block

```
        </ImageDimensions>
        <PixelDimensions>
            <Width>0.02</Width>
            <Height>0.02</Height>
        </PixelDimensions>
        <GPS>
            <Latitude>45.5686684</Latitude>
            <Longitude>2.6551104</Longitude>
            <Altitude>1589.5469</Altitude>
        </GPS>
        <FocalLength>24</FocalLength>
        <FocalLength35mmEq>36</FocalLength35mmEq>
        <Make>FUJIFILM</Make>
        <Model>FinePix S3Pro</Model>
        <LensModel>FinePix S3Pro</LensModel>
        <DateTimeOriginal>2015-04-29T06:40:26</DateTimeOriginal>
    </ExifData> -->
</Photo>
...
</Photogroup>
</Photogroups>
<!-- Control points are highly recommended for accurate positioning. -->
<ControlPoints>
    <!-- Optionally, a different spatial reference system can be specified
with the <SRSId> tag. By default, the SRS of the block is assumed. -->
    <ControlPoint>
        <!-- Control point name and description are optional. -->
        <Name>Control point #1</Name>
        <!-- Optionally, a different spatial reference system can be specified
for each control point with the <SRSId> tag. By default, the SRS of the control
points container is assumed. -->
        <!-- 3D position of the control point in the active spatial reference
system. -->
        <!-- Depending on the SRS, x/y may stand either for longitude/
latitude,
for map projection coordinates, or for something else. -->
        <!-- Depending on the SRS, z may stand either for a geoid height, for
an
orthometric height, or for something else. -->
        <Position>
            <x>652788.0525588237</x>
            <y>6863015.362218254</y>
            <z>78.07000000122935</z>
        </Position>
        <!-- Image measurements. -->
        <Measurement>
            <!-- ID of the photo where the measurement is taken. The
measurements of
a control point must have different photo IDs. -->
            <PhotoId>151</PhotoId>
            <!-- 2D image position of the measurement, in pixels. The origin
is the
center of the upper-left image pixel, the x-axis is oriented to the right side of
the image, and the y-axis is oriented to the bottom of the image. -->
            <!-- Alternatively, a 2D position with respect to the principal
point, in
millimeters. In this case, the xy-axis are oriented according to the
CameraOrientation of the corresponding photogroup. -->
```

## ContextCapture Master

Block

```
        <!-- For this dataset, it would be: -->
        <!-- <xmm>18.6231910176</xmm> -->
        <!-- <ymm>-4.48973352144</ymm> -->
        <x>7270.31</x>
        <y>6599.44</y>
    </Measurement>
    ...
</ControlPoint>
<ControlPoint>
    <Name>Control point #2</Name>
    <Position>
        <x>652123.2211166573</x>
        <y>6863245.976366176</y>
        <z>80.07999999914318</z>
    </Position>
    <!-- If specified, a control point may be a check point (default:
false)-->
    <CheckPoint>true</CheckPoint>
    <!-- If specified, a control point may have accuracies -->
    <HorizontalAccuracy>0.01</HorizontalAccuracy>
    <VerticalAccuracy>0.10</VerticalAccuracy>
    <Measurement>
        <PhotoId>146</PhotoId>
        <x>3296.56</x>
        <y>9253.75</y>
    </Measurement>
    ...
</ControlPoint>
<ControlPoint>
    <Name>Control point #3</Name>
    <!-- If specified, a control point might be Full (default), Horizontal
or
Vertical -->
    <Category>Horizontal</Category>
    <Position> <!-- no z position -->
        <x>652365.1205012415</x>
        <y>6863549.148163618</y>
    </Position>
    <HorizontalAccuracy>0.01</HorizontalAccuracy> <!-- no vertical
accuracy -->
    <Measurement>
        <PhotoId>95</PhotoId>
        <x>3178.26</x>
        <y>4020.21</y>
    </Measurement>
    ...
</ControlPoint>
    ...
</ControlPoints>
    <!-- Known tie points may be used to refine an aerotriangulation. -->
    <!-- Uncomment this section before import to get a single tie point in the
imported block. Please note that a reconstruction created from a such block will
fail. -->
    <!--<TiePoints>
        --><!-- Optionally, a different spatial reference system can be specified
with the <SRSId> tag. By default, the SRS of the block is assumed. --><!--
    <TiePoint>
        --><!-- Tie point name and description are optional. --><!--
```

## ContextCapture Master

Block

```

--><!-- Optionally, a different spatial reference system can be
specified
for each tie point with the <SRSId> tag. By default, the SRS of the tie points
container is assumed. --><!--
--><!-- Optional 3D position of the tie point in the active spatial
reference
system. --><!--
--><!-- Depending on the SRS, x/y may stand either for longitude/
latitude,
for map projection coordinates, or for something else. --><!--
--><!-- Depending on the SRS, z may stand either for a geoid height,
for an
orthometric height, or for something else. --><!--
  <Position>
    <x>652119.8871409688</x>
    <y>6863304.305716386</y>
    <z>87.79328384995461</z>
  </Position>
--><!-- Optional tie point color. --><!--
  <Color>
    <Red>0.59</Red>
    <Green>1.0</Green>
    <Blue>0.0</Blue>
  </Color>
--><!-- Image measurements. --><!--
  <Measurement>
    --><!-- Optional measurement type User or Automatic (Automatic
type is
used if this tag is unspecified). --><!--
    <Type>Automatic</Type>
    --><!-- ID of the photo where the measurement is taken. The
measurements
of a tie point must have different photo IDs. --><!--
    <PhotoId>146</PhotoId>
    --><!-- 2D image position of the measurement, in pixels. The
origin is
the center of the upper-left image pixel, the x-axis is oriented to the right
side of the image, and the y-axis is oriented to the bottom of the image. --><!--
    --><!-- Alternatively, a 2D position with respect to the principal
point,
in millimeters. In this case, the xy-axis are oriented according to the
CameraOrientation of the corresponding photogroup. --><!--
    <x>3324.26001</x>
    <y>9930.269531</y>
  </Measurement>
  <Measurement>
    <PhotoId>158</PhotoId>
    <x>9079.006836000001</x>
    <y>9902.772461000001</y>
  </Measurement>
  <Measurement>
    <PhotoId>162</PhotoId>
    <x>6240.366211</x>
    <y>9896.118164</y>
  </Measurement>
</TiePoint>
</TiePoints>-->
<!-- Optional block's positioning constraints based on user tie point (0
```

## ContextCapture Master

Block

```
based indices). -->
  <!-- Each constraint is optional. -->
  <!--<PositioningConstraints>
    <OriginConstraint>
      <O>2</O>
    </OriginConstraint>
    <ScaleConstraint>
      <A>0</A>
      <B>3</B>
      <DistanceAB>56.350</DistanceAB>
    </ScaleConstraint>
    <AxisConstraint>
      <A>0</A>
      <B>3</B>
      <AxisAB>z</AxisAB> --><!-- x, y, or z --><!--
    </AxisConstraint>
    <OrientationConstraint>
      <A>0</A>
      <B>3</B>
      <C>2</C>
      <AxisAB>z</AxisAB> --><!-- x, y or z --><!--
      <AxisSideC>upperX</AxisSideC> --><!-- lowerX, upperX, lowerY,
upperY,
lowerZ, or upperZ --><!--
    </OrientationConstraint>
  </PositioningConstraints>--><PointClouds>
  <PointClouds>
    <PointCloud>
      <Name>PointCloud name</Name>
      <Description>Description of the pointcloud</Description>
      <Path>Absolute or relative path to the POD pointcloud
file</Path>
      <CreatedDateTime>2017-05-26T15:59:08</CreatedDateTime>
      <SRS>SRS definition</SRS> (can be empty)
      <BoundingBox>
        <XMin></XMin>
        <XMax></XMax>
<YMin></YMin>
        <YMax></YMax>
        <ZMin></ZMin>
        <ZMax></ZMax>
      </BoundingBox>
      <MinResolution>0.0232077879728498</MinResolution>
      <MedResolution>0.0480807854162596</MedResolution>
      <MeanResolution>0.0779783209951879</MeanResolution>
      <MaxResolution>4.71837838822922</MaxResolution>
      <ColorMode></ColorMode><!-- UseIntensity or UseColor or None -->
    <Scans>
      <Scan>
        <Name>Scan name</Name>
        <NumPoints>320519</NumPoint>
        <Attributes>2</Attributes>
        <!-- If static scan -->
        <SourcePosition>
          <x>0.05</x>
          <y>18.59</y>
          <z>58.369</z>
        </SourcePosition>
```

```
<!-- If mobile scan -->
  <Trajectories>
    <Trajectory>
      <Point>
        <x>0.05</x>
        <y>18.59</y>
        <z>58.369</z>
      </Point>
      ...
    </Trajectory>
  </Trajectories>
</Scan>
</Scans>
  </PointCloud>
</PointClouds>
</Block>
</BlocksExchange>
```

You can find the above example and specification file in ContextCapture installation directory:

For more information about ContextCapture camera model, see also [ContextCapture camera model](#) (on page 217).

## MS Excel block definition

Blocks definition can be provided in MS Excel documents according to a format specified by Bentley.

This format is provided for convenience to ease block import from pre-existing MS Excel documents in XLS or XLSX format. However, we recommend you to use the more flexible [BlocksExchange XML/XMLZ format](#) (on page 119) in the general case.

In an MS Excel file, the block definition can be partial or complete, and data can be provided in different form.

You can find an example and a template in ContextCapture installation directory:

- doc/BlockImportSample.xls
- doc/BlockImportTemplate.xls

## Data worksheets

In the MS Excel file, the data is provided in several worksheets.

 XLS format is limited to 16384 rows, use XLSX format instead if you want to import larger dataset.

### Photogroups

List of photogroups with corresponding parameters:

- Name: unique name of this Photogroup (mandatory)
- Width, Height: image size in pixels (mandatory)
- FocalLength: focal length in mm (mandatory)
- SensorSize or PixelSize: in mm (mandatory)
- PrincipalPointX, PrincipalPointY: principal point position in pixels (optional)
- PrincipaPointLXmm, PrincipalPointYmm: principal point position in mm (optional)
- CameraOrientation: camera orientation reference, see [BlocksExchange XML/XMLZ format](#) (on page 119) (optional)

# ContextCapture Master

Block

---

- K1, K2, K3, P1, P2: lens distortion coefficients (optional)

## Photos

List of photos with corresponding parameters:

- Name: file name (mandatory)
- PhotogroupName: name of the attached camera (mandatory)
- Directory: base directory (optional)
- Extension: file suffix (optional)
- Longitude, Latitude, Height or Easting, Northing, Height: 3D position (optional)
- Omega, Phi, Kappa or Yaw, Pitch, Roll, or Heading, Roll, Pitch: rotation, in degrees or radians according to options (optional)

Photo *Name* can be an absolute path, a relative path, or a file name:

The actual photo path is built using optional option BaseImagePath, optional photo Directory, photo Name, and optional Extension .

## ControlPoints

List of control points with name and 3D position.

To provide control points measurements, use the [BlocksExchange XML/XMLZ format](#) (on page 119) instead.

## Options

Options used to interpret the MS Excel file.

## SRS

*Spatial reference system used to interpret 3D positions and rotations.*

Supports EPSG code ("EPSG:XXX"), PROJ.4 or WKT definition.

## InRadians

Specify that orientation angles are provided in radians rather than in degrees.

## BaseImagePath

Optional base directory used to build photos absolute path.

## BlockType

Optional block type.

## AExport XML format

The AExport XML format contains interior and exterior orientation data for each photo:

- ImagePath: image file path,
- ImageDimensions: image width and height in pixels,
- CameraModelType: *Perspective* or *Fisheye*,
- FocalLength: focal length in pixels,
- FisheyeFocalMatrix: focal matrix in pixels used only for the camera model type *Fisheye*,
- AspectRatio: image aspect ratio,
- Skew: image skew,
- PrincipalPoint: principal point position in the image in pixels,

# ContextCapture Master

## Block

- Distortion: lens distortion coefficients used only for the camera model type *Perspective*,
- FisheyeDistortion: lens distortion coefficients used only for the camera model type *Fisheye*,
- Rotation: photo rotation (if georeferenced, given in ECEF),
- Center: photo position (if georeferenced, given in ECEF).
- Skew: skew coefficient defining the angle between x and y pixel axes.
- Aspect ratio: different from 1 if the pixel are not square.

⚠ The ATEExport XML format is made for exporting to 3rd party software only. You must use the [BlocksExchange XML/XMLZ format](#) (on page 119) if you want to later re-import blocks in ContextCapture.

## Camera database

The camera database manages the list of camera models that ContextCapture applies automatically when adding photos, or that you can explicitly apply on photogroups.

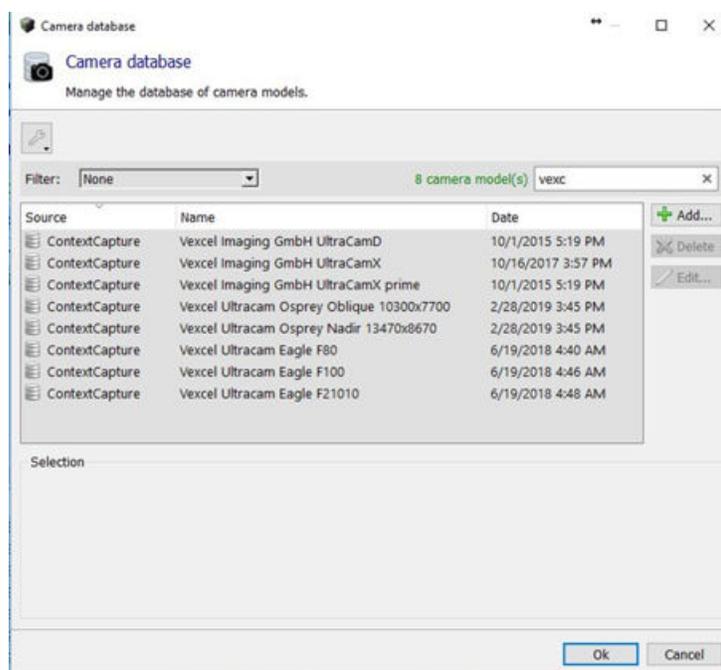


Figure 68: The camera database dialog

The camera database contains two kinds of items:

- ContextCapture items are default camera models provided by ContextCapture . These items are read-only and the item list is updated daily by the ContextCapture support team.
- User items are camera models you added or imported on your computer.

Each camera model is made of a name (alias), a date (last modified), various (optional) optical properties, and search/matching criteria.

For more information about the optical properties, see [Photogroups](#) (on page 49).

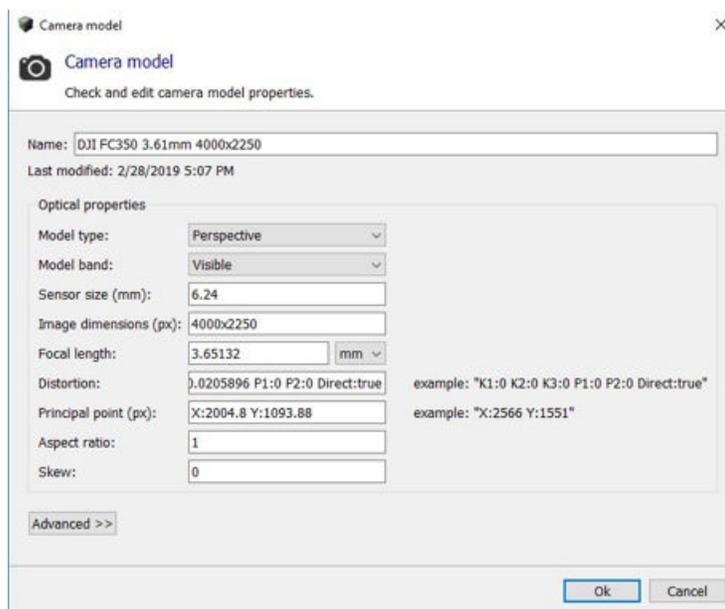


Figure 69: The camera model dialog

## Apply a camera model from the database

### Apply a camera model automatically when adding photos

When adding photos from the block's Photos tab, ContextCapture automatically uses the camera database to get the best camera model for the added photos.

ContextCapture uses input photos properties (Exit data and image dimensions) to find the best camera model in the database according to its properties and matching criteria.

**Note:** More recent items and user items are used in priority.

### Apply a camera model manually to a photogroup

See [Apply a camera model manually to a photogroup](#) (on page 130) for additional information.

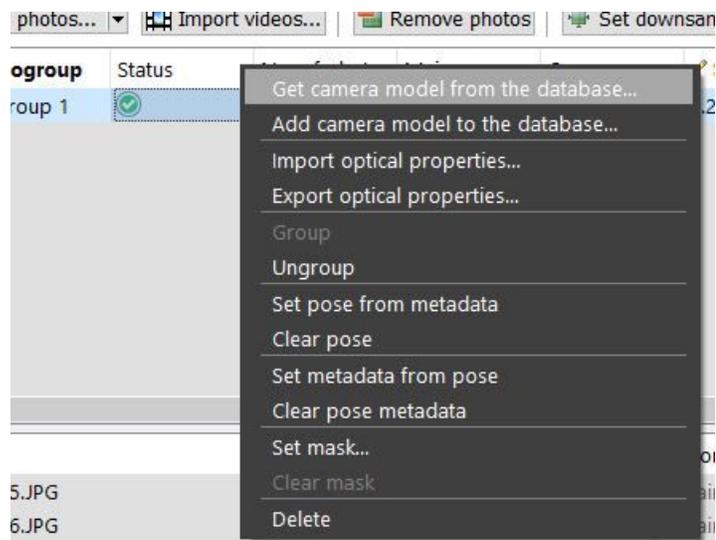
### Apply a camera model manually to a photogroup

Once photos are added, it is also possible to get a camera model manually from the database for a given photogroup:

1. Right click on the photogroup and call *Get camera model from the database*.

# ContextCapture Master

Block



*Figure 70: Accessing the camera database from a photogroup*

2. In the *Camera database* dialog, use the provided filters to search for a suitable camera model.

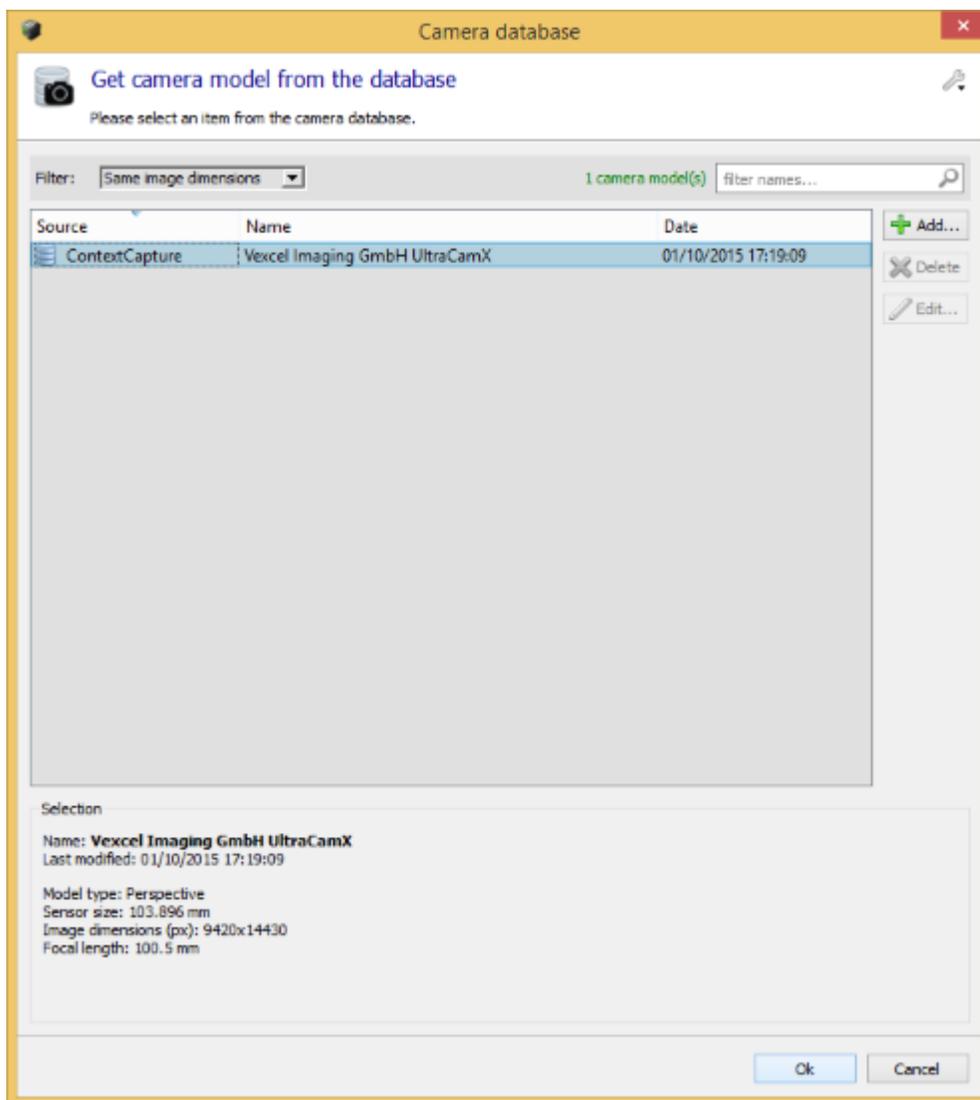


Figure 71: Searching a camera model in the camera database dialog

3. Click on *OK* to apply the selected camera model to the photogroup.

## Manage the user camera database

There are two ways of accessing and managing the user camera database:

- At photogroup level, from the block's *Photos* tab. This access mode allows you to quickly add the photogroup's camera model to the database.
- At application level, from the ContextCapture options: menu *Options* > Manage camera database. This mode can be used for more complex operations, such as edition or deletion of previously added camera models.

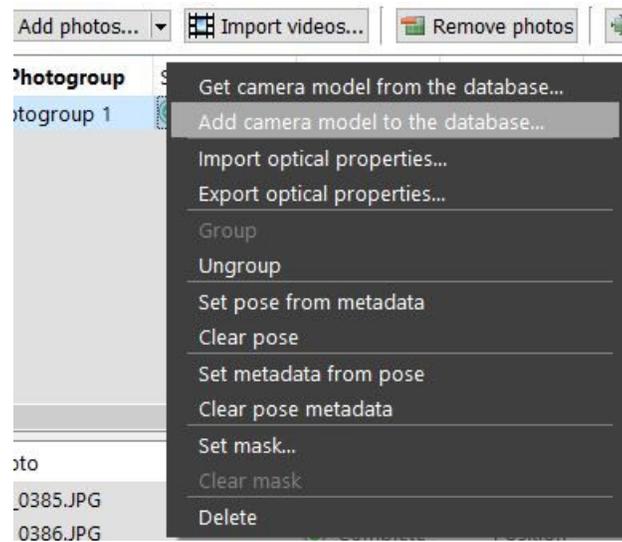


Figure 72: Importing/exporting user camera database

## Adding the camera model of a photogroup

See [Adding the camera model of a photogroup](#) (on page 133) for additional information.

## Editing the camera database

The camera database dialog can be accessed from the ContextCapture options: menu *Options > Manage camera database*. Using this dialog, new user items can be added, and existing items can be edited or deleted.

Please note that ContextCapture items are not editable.

## Import/export user camera database

To save your customized items, or to move them to another computer, you can use the import/export functions available from the tool menu.

## Adding the camera model of a photogroup

1. Right click on the photogroup and call *Add camera model to the database*.

# ContextCapture Master

## Reconstruction

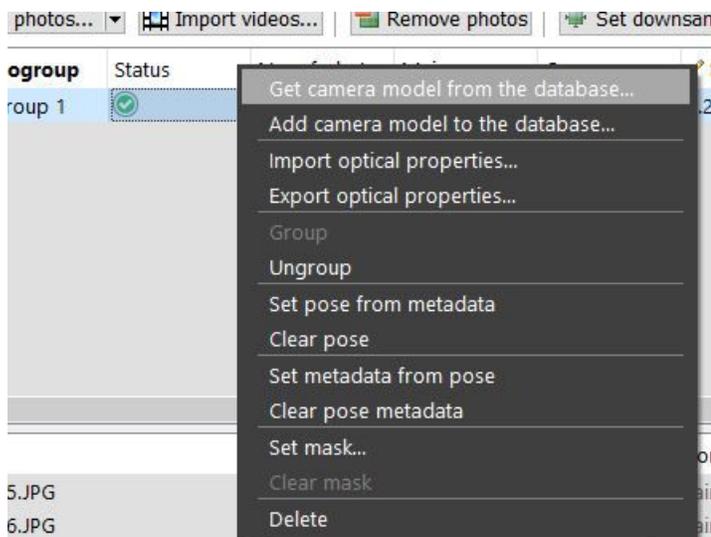
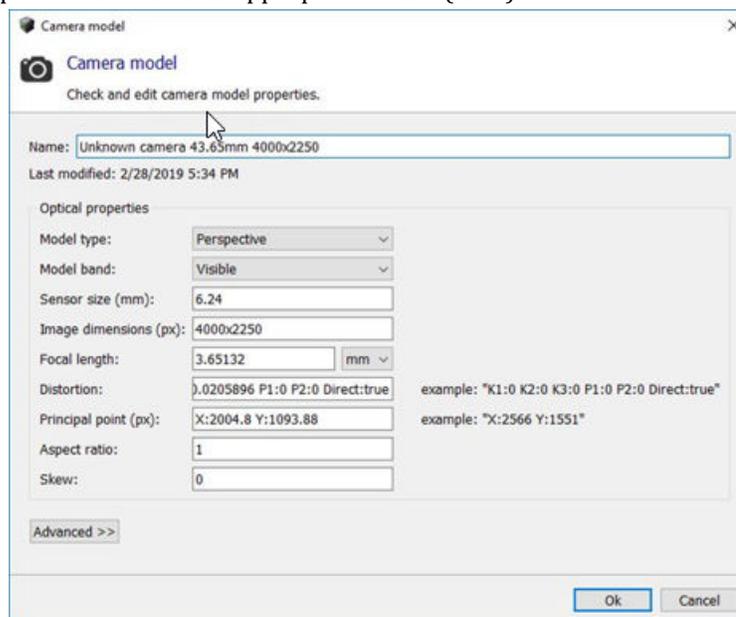


Figure 73: Adding a photogroup camera model to the database

2. Check the optical properties and enter an appropriate name (alias).



3. Click on *OK* to add the camera model to the user camera database.

User-added camera models are automatically used by ContextCapture when adding new photos taken with the same camera. For this, ContextCapture relies on the camera model's matching criteria.

## Reconstruction

A Reconstruction item manages a framework to create 3D reconstruction or orthophoto/DSM (spatial reference system, region-of-interest, tiling, constraints, retouching, processing settings). Based on the reconstruction item, one or several productions can be launched.

# ContextCapture Master

## Reconstruction

Two reconstruction types are available:

- **3D reconstruction:** true 3D model suited for reality mesh and by-products creation.
- **Orthophoto/DSM:** simplified 2.5D model dedicated to high quality orthophoto and DSM creation from photos.

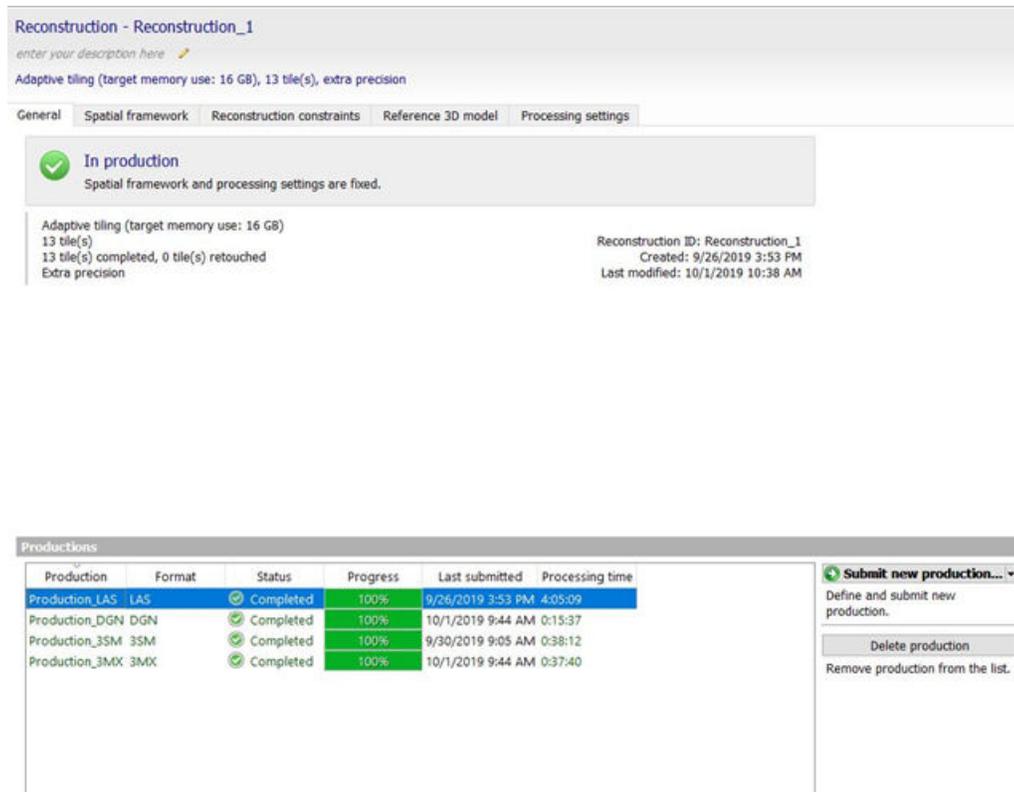


Figure 74: The reconstruction interface

The reconstruction is defined by the following properties:

- [Spatial framework](#) (on page 137) defines spatial reference system, region of interest and tiling. It also includes resolution settings for an orthophoto/DSM.
- [Geometry constraints](#) (on page 141) allows the use of existing 3D data to control the reconstruction and to avoid reconstruction errors.
- [Reference model](#) (on page 142) is the reconstruction sandbox, it stores a model in native format which is progressively completed as productions progress. This reference model is the model to which retouches and reconstruction constraints are applied, and from which future productions are derived.
- [Processing settings](#) (on page 144) sets geometric precision level (high, extra, etcetera) and other reconstruction settings.
- List of productions.

**Note:** *Spatial framework* and *processing settings* must be edited before starting the production. Once the production is started the *Spatial framework* tab is read-only. In this case, you can clone the reconstruction to get a new fully editable reconstruction framework.

### General

The General tab manages the reconstruction dashboard and the list of productions.

### Dashboard

The dashboard provides information on the status of the reconstruction as well as on the main spatial framework settings.

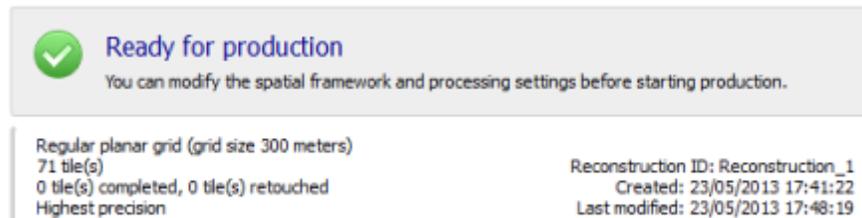


Figure 75: Reconstruction dashboard

### Productions

List of productions of the reconstruction.

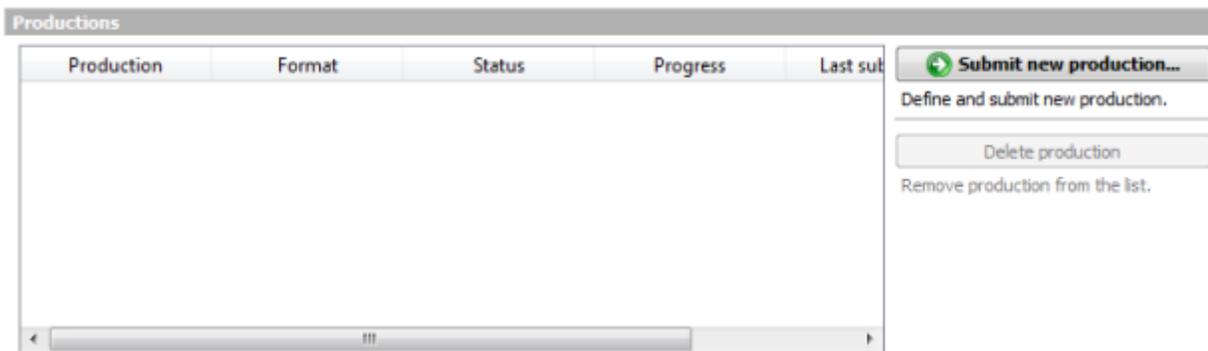


Figure 76: Reconstruction productions

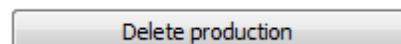
Several productions can be generated from a same reconstruction. They will share same reconstruction settings (SRS, tiling, region of interest, processing settings, ...).

Some operations can be executed from the reconstruction *General* tab:



Submit a new production on ContextCapture Engine or on ContextCapture Cloud service.

See [Creating a new production](#) (on page 159) and [Process on the cloud](#) (on page 100).



Remove production from the list.

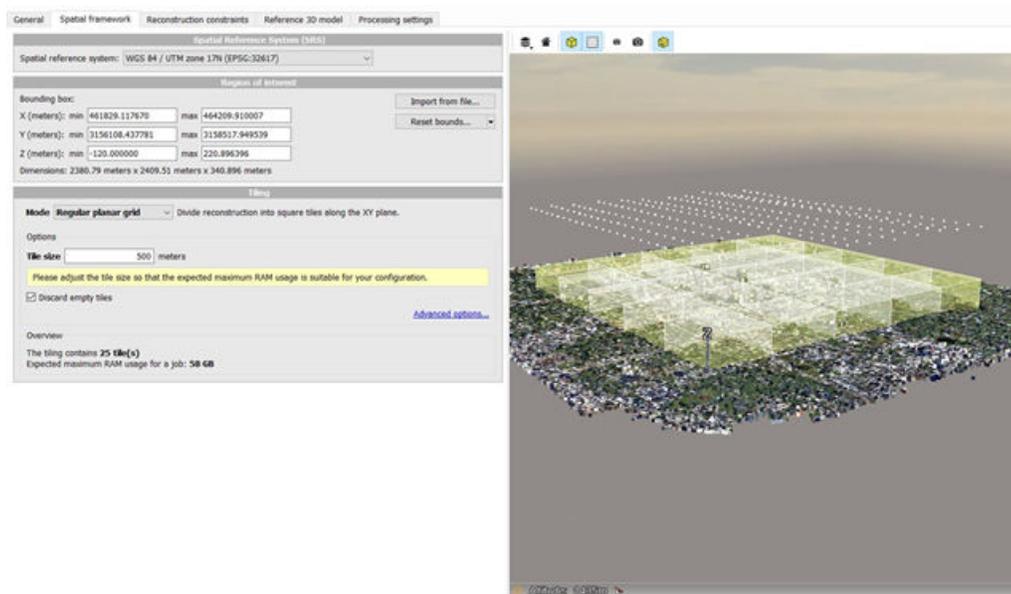
This only removes references to the production from the project. The output files of the production, if any, are not affected.

See [Production](#) (on page 158) also for more details on productions.

## Spatial framework

The Spatial framework tab is dedicated to the definition of the reconstruction 3D workspace, including spatial reference system, region of interest and tiling.

**Note:** The *Spatial framework* must be edited before starting the production. Once the production is started, the Spatial framework tab is read-only.



## Spatial reference system (SRS)

*Available only for georeferenced project, defines the coordinate system used by the Spatial framework, for both Region of interest and Tiling.*

Any well-known SRS definition can be entered, see [Spatial reference system](#) (on page 192).

By default, the reconstruction uses a Local East-North-Up (ENU) system with an origin set on the center of the model.

Some SRS define both the coordinate system and tiling. It is the case for [Spatial framework](#) (on page 137).

For non-georeferenced projects, the reconstruction uses the block local coordinate system.

The reconstruction Spatial reference system is used as reference for region of interest and tiling, whereas output 3D model coordinates of productions depend on another Spatial reference system, which you can select at production level.

## Resolution (orthophoto/DSM)

For a reconstruction of type n orthophoto/DSM reconstruction-type, defines the target resolution for the reference orthophoto/DSM.

### Region of interest

*Defines the maximum area of the reconstruction.*

The *Region of Interest* is set thanks to an axis-aligned 3D box in the spatial reference system of the reconstruction.

By default, the region of interest automatically focuses on areas of significant resolution: in each photograph, statistics on the resolution of the block tie points are computed, and points in the core of the distribution are selected. The region of interest is defined as the bounding box of these selected block tie points. The Reset bounds... button allows to reset the region of interest to the above default settings (Smart mode), or to the bounding box of the block tie points, obtained after rejecting gross outliers only (Maximal mode). The Maximal mode is likely to include distant background areas in the region of interest and to require some manual adjustment of the region of interest.



*Edit region of interest*

Click on this button to edit the region of interest interactively in the 3D view.

Move bounding box faces to set the region of interest.

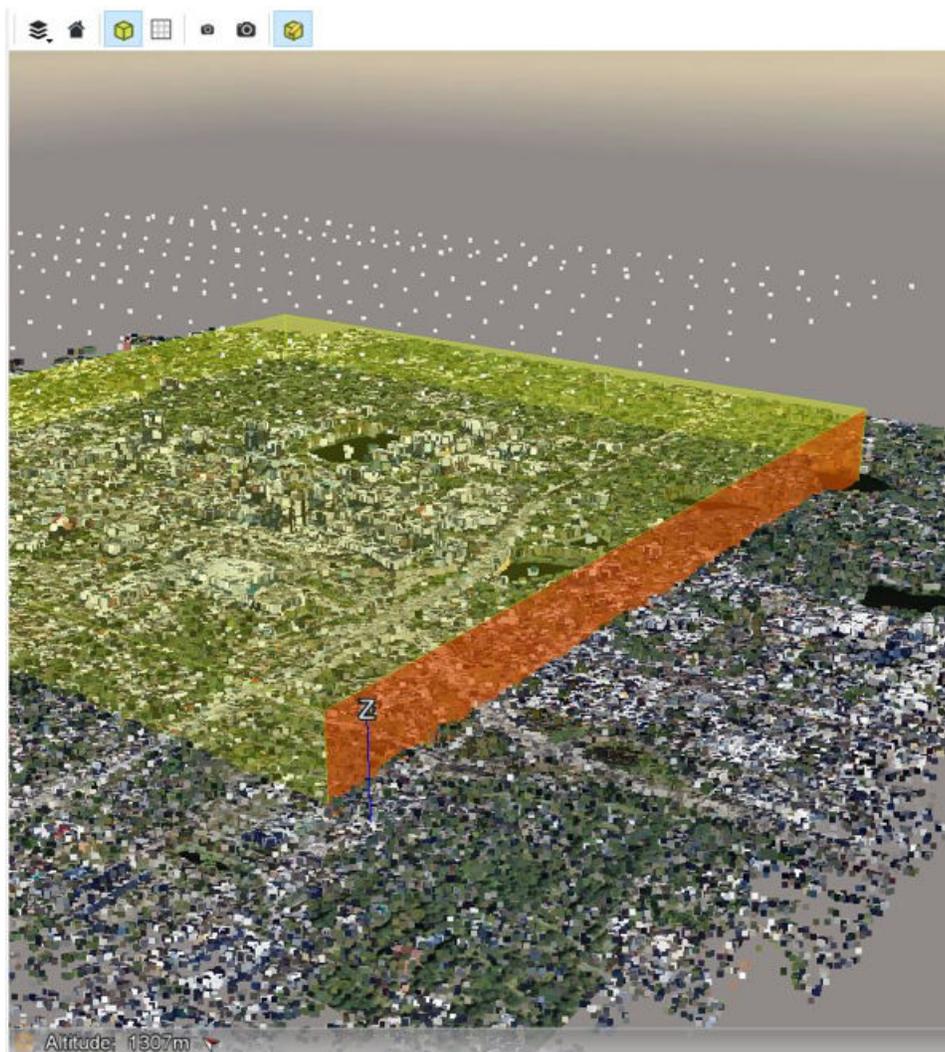


Figure 77: Interactive edition of the region of interest

An extruded polygon can be used to define the area more precisely from a DGN or from a KML file (if reconstruction is georeferenced). Click on the button Import from polygon to specify the region of interest from a KML or a DGN file. The polygon file only defines a 2D polygon: top and bottom height can be defined from the interface.

**Note:** It is sometimes relevant to define a region of interest which is smaller than the default bounding box (for example, to discard distant background areas from the reconstruction, when the Smart mode does not detect them automatically). However, in some cases, notably when the block tie points do not cover some interesting parts of the scene (for instance, a high isolated building), it is useful to enlarge the default region of interest.

## Tiling

Select how to divide the reconstruction task.

3D models generated by ContextCapture can span entire cities and hence may not fit in your computer's memory in one piece. Thus, it is often necessary to divide them into tiles.

Four tiling modes are available:

- No tiling: Do not subdivide reconstruction.
- Regular planar grid: Divide reconstruction into square tiles along the XY plane.
- Regular volumetric grid: Divide reconstruction into cubic tiles.
- Adaptive tiling: Adaptively subdivide reconstruction into boxes to meet a target memory usage. This is particularly useful to reconstruct a 3D model with a highly non uniform resolution, e.g. when reconstructing a city from aerial images and ground images of a few landmarks. In such a case, it is not possible to find a regular grid size adequate for all areas.

### Tiling options

When using a tiling other than an adaptive tiling, select tile size and tiling origin (click on *Advanced options*) depending on your needs.

Tiling is aligned to the selected spatial reference system. Tiles are discarded if they are completely outside of the region of interest, or if they do not contain any block tie point.

By default, tiles not containing any tie point are discarded from the tiling, enable the option Discard empty tiles to keep all tiles in the specified region of interest.

**Note:** To preview the tiling in the 3D view, choose Tiling in the Show combo-box.

For georeferenced reconstructions, tiling can be exported in KML format (menu *Reconstruction > Tiling > Export to KML ...*) to get an overview of the spatial framework in a standard GIS tool or in *Google Earth*.

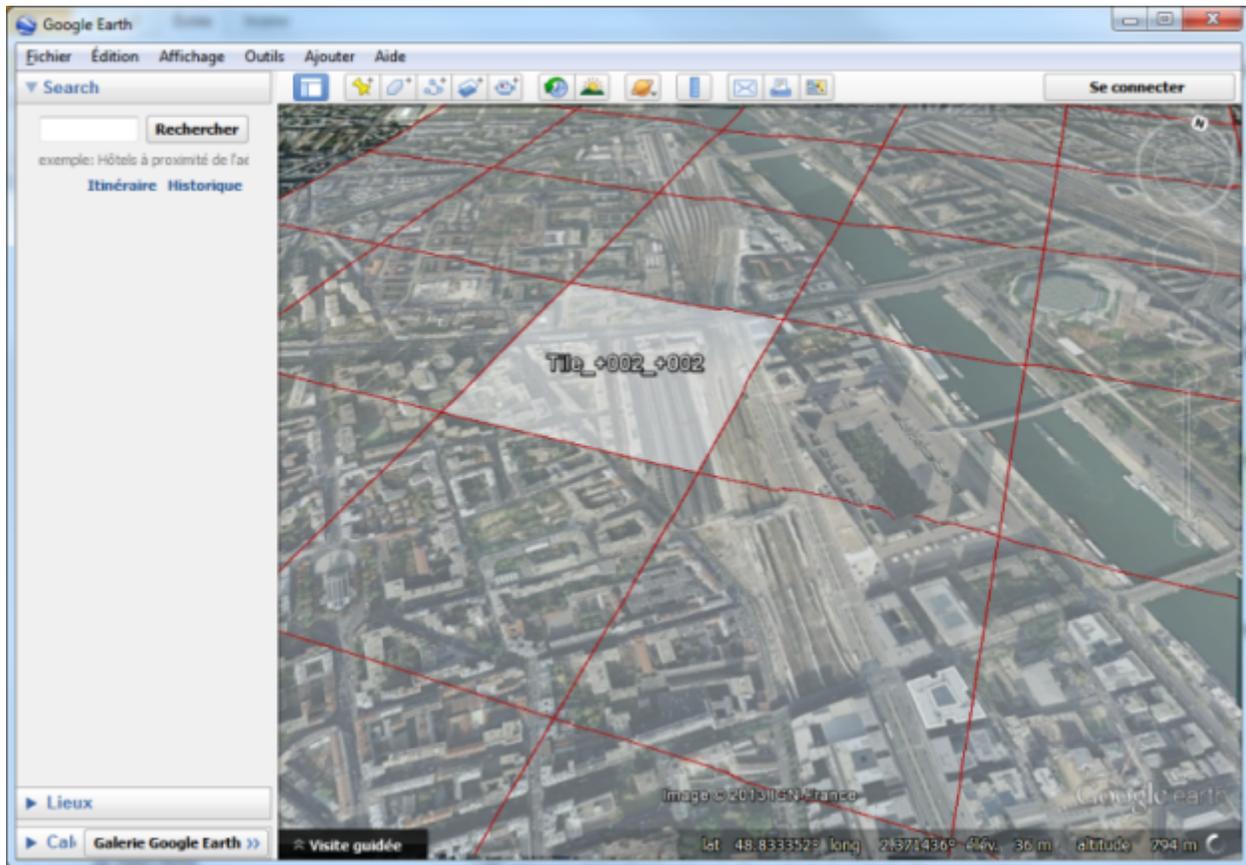


Figure 78: Tiling overview in Google Earth

## Bing Maps Tile System

ContextCapture allows to perform reconstruction following the [Bing Maps Tile System](#).

Select a Bing Maps spatial reference system to setup a reconstruction using a Bing Maps coordinate system and tiling for a given level.

## Geometry constraints

The Geometry constraints tab allows the use of existing 3D data to control the reconstruction and avoid reconstruction errors.

Geometry constraints are available only in ContextCapture Center Edition. See [Software Editions](#) (on page 27).

In some cases, the automatic reconstruction may have reconstruction errors that need to be fixed. It may occur for instance on unseen areas, on reflective parts or on water surfaces.

Rather than fixing problems after the reconstruction with a 3rd party tool (refer to [Retouching](#) (on page 187)), ContextCapture can consider existing 3D data to help the reconstruction process on areas where photos are not sufficient.

# ContextCapture Master

## Reconstruction

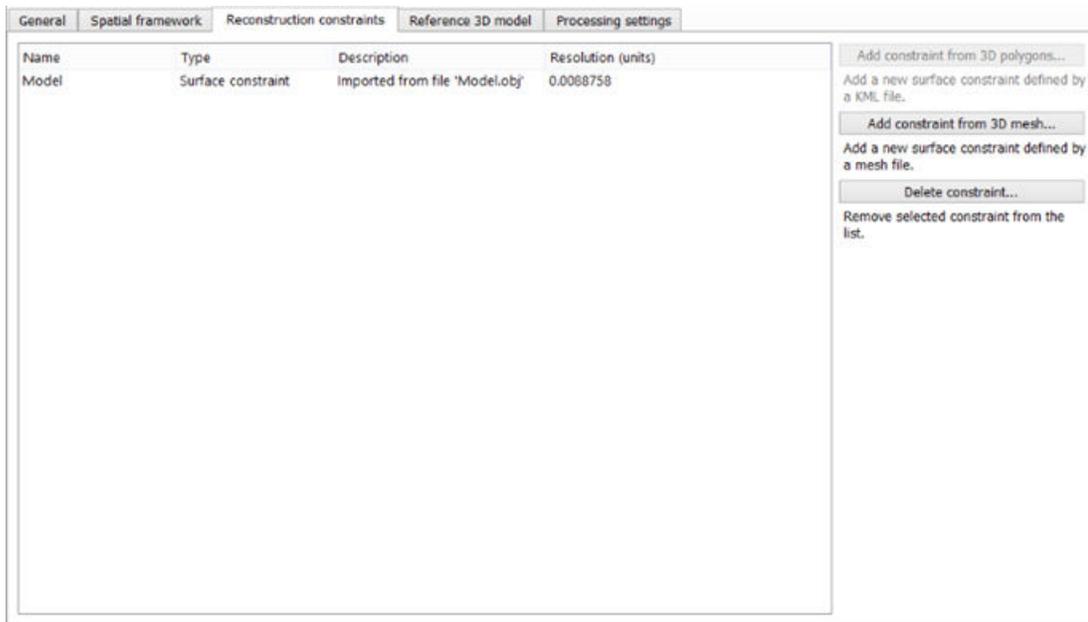


Figure 79: Reconstruction constraints tab

You can define geometry constraints at any time during the workflow. If the reference model already exists, tiles overlapping the reconstruction constraint will be reset: they will be recomputed in later productions, by taking into account the new geometry constraints.

ContextCapture can use geometry constraints defined from:

- A KML or a DGN file containing 3D polygons (only for georeferenced reconstructions),
- An OBJ or a GDN file containing a 3D mesh.

For georeferenced project, the imported file can use any spatial reference system. Please select the spatial reference system and the origin accordingly.

For non georeferenced projects, the spatial reference system of the input file must correspond to that of the internal reconstruction.

ContextCapture uses this data as a soft constraint in the reconstruction process: a reconstruction constraint is used only if there is no other reliable data in the area: wherever reliable 3D information can be inferred from input photos, it will override the reconstruction constraint.

**Note:** It is often much more efficient to create constraints in a GIS software (based on an existing ortho-image for instance) than to fix errors of the automatically produced 3D model in a 3D modeling software.

## Reference model

The Reference model tab manages the internal model of the reconstruction. It allows you to control model quality, to apply retouches or reset the reconstruction.

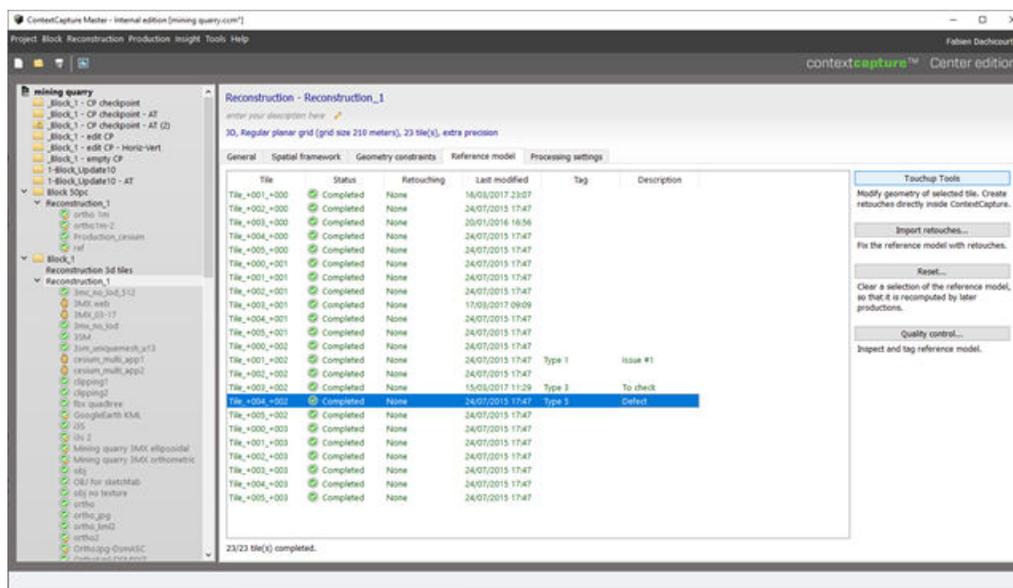


Figure 80: Reference 3D model tab

The reference model is the reconstruction sandbox. It stores internally a model which is progressively completed as productions progress, to which retouches can be applied, and from which future productions are derived.

The reference model is managed tile by tile, and each tile can be controlled individually.

An *Unprocessed* tile without retouch becomes *Completed* as soon as a production including this tile is complete.

### Model contents

For a 3D reconstruction, a tile is made of a textured 3D mesh in native format ; for an orthophoto/DSM, a tile is made of a DSM file and an orthophoto file in TIF format.

Tiles of a 3D reconstruction may be displayed individually in ContextCapture Viewer: from the tile context menu (right click), choose *Open tile with ContextCapture Viewer*.

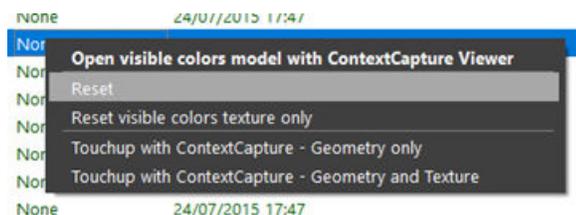


Figure 81: Tile context menu

**Note:** To ease quality control of a 3D reconstruction, it is advised to perform a first complete production in 3MX or S3C formats: 3MX and S3C formats include dynamic level-of-detail and paging and allows you to smoothly navigate the entire reconstruction in ContextCapture Viewer or in the integrated *Quality control* interface.

To manage the reference model, the following features are proposed:

- [Touchup](#) (on page 149): Fix the current reference model with retouches.
- [Reset](#) (on page 154) Clear a selection of the reference model, so that it is recomputed by later productions.

# ContextCapture Master

## Reconstruction

- [Software Editions](#) (on page 27): Inspect and tag reference model tiles.
- [Inter-tile color equalization](#) (on page 155).

## Processing settings

The Processing settings tab allows you to choose reconstruction processing settings, including geometric precision and advanced settings.

**Note:** Processing settings must be edited before starting the production. Once the production is started the Processing settings tab is read-only.

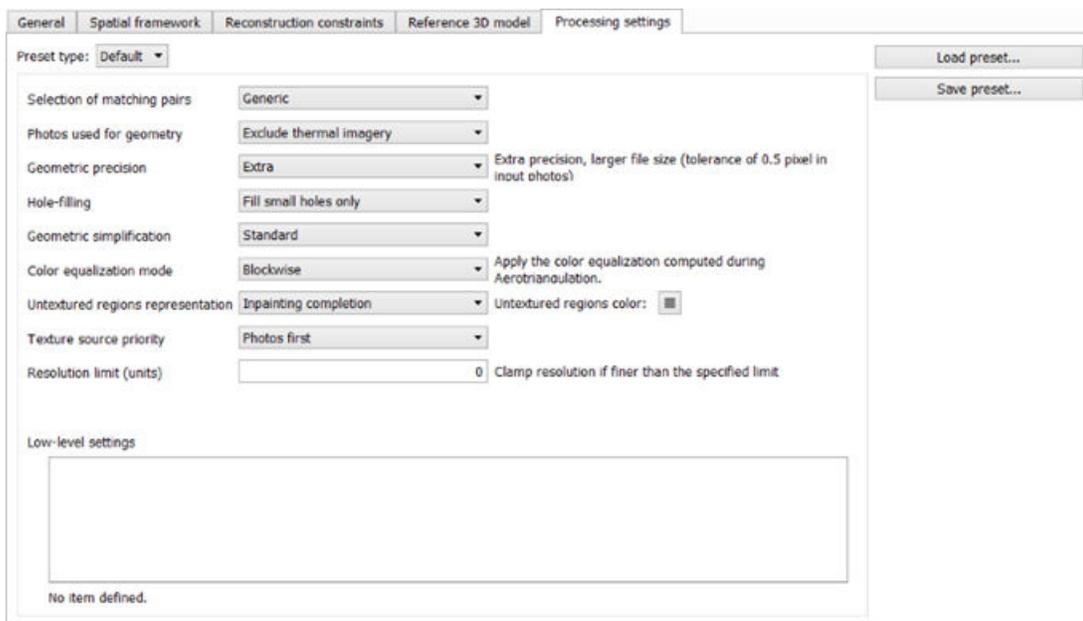


Figure 82: Processing settings tab

### Selection of matching pairs

This advanced option allows you to optimize the matching pair algorithm for your particular input image dataset:

- Generic (default): advised for most image datasets.
- For structured aerial flight: advised for structured aerial image datasets only, acquired with a regular sweep of the area in parallel lines, and sensors with fixed lever arm angles.
- Focus on ROI: advised for vertical structure captured following orbit path.

### Photos used for geometry

This advanced option allows you to choose the input data used for reconstructing geometry.

- Exclude thermal imagery: advised when thermal imagery resolution is not sufficient for photogrammetry. In this case, only photos with visible colors band are used for geometry. This is the default whenever photos with visible colors are available.

- Include thermal imagery: geometry will use all available photos.
- None: geometry will use only point clouds (available only if input block has point clouds).

### Geometric precision

This option specifies the tolerance level in input photos, which results in more or less detail in the computed 3D model:

- Ultra: ultra high precision. Warning: highly memory and computation time consuming, not recommended for large areas.
- Extra (default): extra precision, larger file size (tolerance of 0.5 pixel in input photos).
- High: high precision, smaller file size (tolerance of 1 pixel in input photos).
- Medium: medium precision, best suited for Orthophoto/DSM productions (tolerance of 2 pixels in input photos). The fastest and most memory-efficient mode.

### Computation time and memory requirements

*High* and *Extra* modes are similar in terms of computation time and memory consumption.

*Ultra* mode is 4 times slower, and takes 4 times more memory than *High* or *Extra* mode.

*Medium* mode is 2-3 times faster, and takes 4 times less memory than *High* or *Extra* mode.

### Hole-filling

This option gives you control over the hole-filling algorithm:

- Fix small holes only (default): advised for most datasets.
- Fix all holes except at tile boundaries: reinforce the hole-filling algorithm to minimize the number of holes in the mesh. With this option, the algorithm tries to enforce a closed surface.

**Note:** This last option may create aberrant geometry to fill large holes. However, retouching these aberrant parts may be easier than filling unwanted holes.

### Geometric simplification

- Standard (default): standard geometric simplification based on mesh decimation.
- Planar: geometric simplification based on plane detection.

This algorithm strives to find planar surfaces (like walls and roofs) and ensures they remain planar during the reconstruction and simplification stages.

The planar simplification is based on a tolerance threshold:

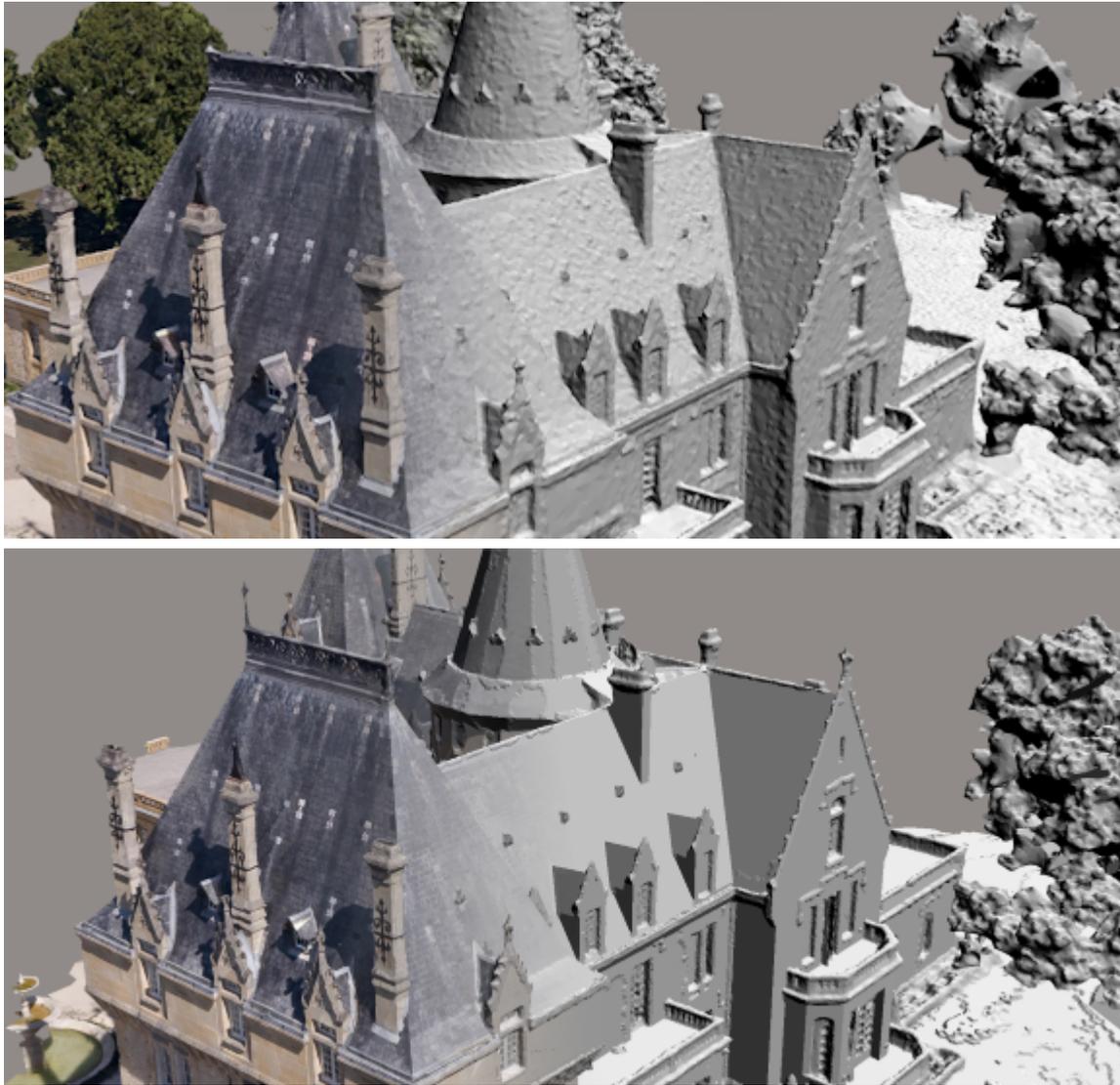
If provided in pixels, the tolerance is defined in pixels in input photos: the simplification depends on input photos resolution.

If provided in meters (or units for non-georeferenced blocks), the tolerance is defined in the 3D coordinate space: the simplification is uniform over the 3D model.

# ContextCapture Master

## Reconstruction

---



3D reconstruction of an area, without (top) and with (bottom) planar simplification.

### Color equalization mode

ContextCapture generates the 3D model texture from various input photos that may have been acquired in different lighting conditions.

To reduce radiometric differences between input photos in the 3D model texture, ContextCapture proposes two ways to automatically perform color equalization on the input photos.

This color equalization mode option lets you change the color equalization algorithm used to process the texture:

- Standard: the default advanced ContextCapture automatic color equalization performed on each tile independently.
- Blockwise: a new color equalization algorithm, generally more flexible than the standard algorithm, and able to deal with greater radiometric differences between images. Note that this automatic equalization is

# ContextCapture Master

## Reconstruction

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computed during the aerotriangulation for all input photos. This dispenses with the need for a second, inter-tile color equalization, sometimes needed in the Standard method.

To have this option activated, you need to enable Blockwise color equalization in the aerotriangulation settings.

- Standard (including thermal): This mode will apply the standard color correction on the thermal photos also.

Warning: This will change the input temperature values, and might result in incorrect output data.

- Blockwise (including thermal): this mode will apply the blockwise color correction on the thermal photos also.

Warning: This will change the input temperature values, and might result in erroneous output data.

- None: disable color equalization. Initial color of input photos will be kept in the generated texture.

This option should be used only if input photos have been acquired with constant and homogeneous lighting.



Example result when the input photos have different exposures: (left or top) Standard Mode; (right or bottom) Blockwise mode.

# ContextCapture Master

## Reconstruction

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### Untextured regions representation

In some cases, even if parts of the scene are not seen by input photos, ContextCapture is able to create geometry conforming to neighboring parts.

You can choose how ContextCapture will texture them:

- Inpainting completion (default): fill small and medium untextured regions by image inpainting. This method is not applicable for large untextured regions: the latter are filled with the color you have selected for untextured regions.
- Uniform color: fill all untextured regions with the color you have selected.
- Untextured regions color: custom color used to fill untextured regions.



3D reconstruction of an area with untextured regions, without (left or top) and with (right or bottom) inpainting completion.

### Texture source priority

When the input block contains both photos and point clouds, this option allows to select the texturing source priority:

- Smart: ContextCapture will select the best source locally, according to the resolution.
- Point clouds first: Point clouds color will override photos.
- Photos first: photos will override point clouds color.

### Resolution Limit

By default, ContextCapture generates a 3D model with a resolution automatically adapted to the resolution of the input photographs. However, some applications may require to control the output resolution more tightly. The resolution limit setting allows to clamp the resolution of the output 3D model to a user-specified limit in meters (or in units for non-georeferenced reconstructions). If the resolution of the input photos is finer than the limit in some areas, the 3D model will be generated with a resolution equal to the specified limit in these areas. By default, the resolution limit is set to zero, so that the resolution is never clamped.

### Low-level settings

Low-level settings can be set only through loaded presets. They can control directly all reconstruction processing settings.

Reconstruction presets may be provided by Bentley System's technical support team to solve specific issues.

### Touchup

*Fix the current reference 3D model with retouches.*

Retouches consist of modifying tiles including geometry and/or texture which are used to replace the automatically generated model by ContextCapture .

To perform retouches, you must:

1. Produce tiles in any format (preferably OBJ for retouching).
2. Apply tile corrections with ContextCapture Touchup Tools or with some third-party software (Refer to [Retouching](#) (on page 187)).
3. Import retouched tiles (if done in third party tool).

Two levels of retouching are possible:

- Geometry: the retouched model replaces the geometry of the reference 3D model (texture of the retouched model is ignored). The texture of the reference 3D model will be re-processed in further productions whereas geometry will be preserved.
- Texture and geometry: the retouched model becomes the reference 3D model, including texture and geometry. Texture and geometry will be kept as is in further productions.

### Touchup Tools

Modify the geometry of selected tiles within ContextCapture.

ContextCapture embeds a dedicated user interface to fix common defects on reference model tiles. Only the geometry can be modified with this tool.

Select a completed tile, and click Touchup Tools to open it in the Touchup user interface.

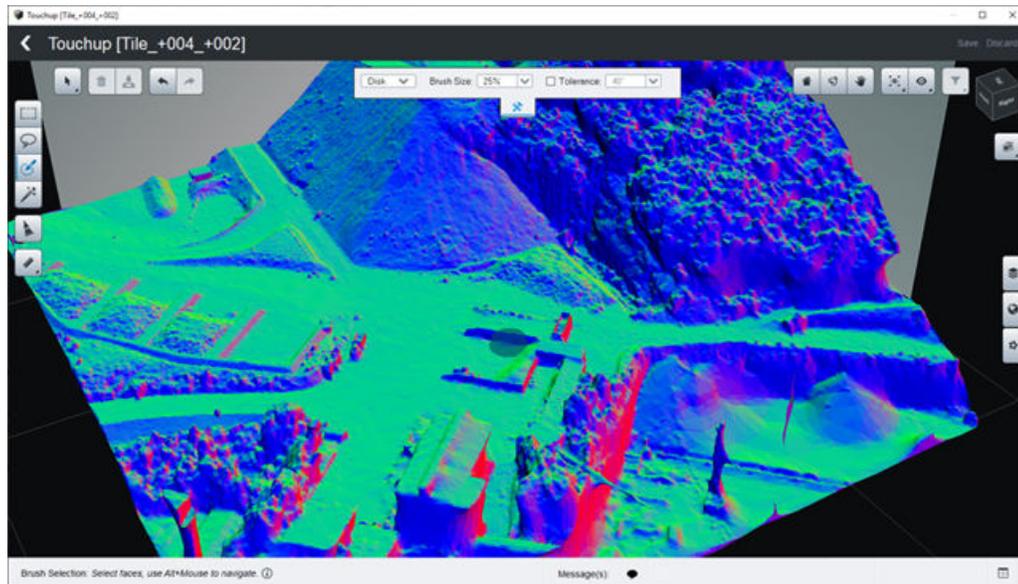


Figure 83: Touchup user interface: control and fix reference model geometry.

There are two ways to proceed to touchup within this interface:

1. Select faces and apply fixes.

Many tools - from basic rectangle to smart selection - are provided to allow accurate facet selection.

Two fixes are possible: Delete faces, or Erase and Fill.

2. Use the Mesh Cleaning tool: this tool automatically detects various kind of defects -Holes and Small components- and allow to fix them automatically.

#### **Selection**

Rectangle and Lasso

Draw a rectangle or an arbitrary region to select the underlying faces.

#### **Brush**

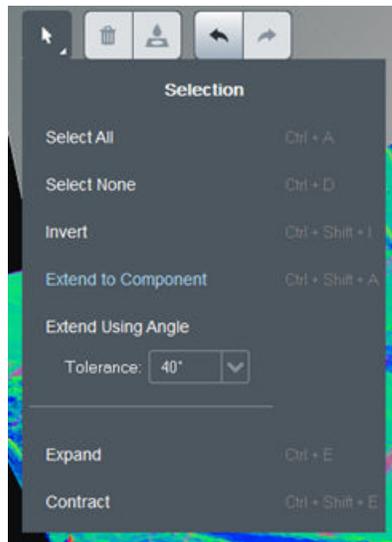
Use a 3D brush to select faces with topology constraints.

#### **Smart Selection**

Draw strokes on areas that are in/out your targeted selection

#### **Modify the selection**

The selection can be modified with the commands accessible from the Selection menu.



### Action on Selection

#### Delete

Remove the selected faces.

#### Erase and Fill

Remove the selected faces, and fill the freshly created hole.

#### Mesh Cleaning

This tool automatically detects various kinds of defect and allows to fix them automatically.

Two types of defects are managed:

- Holes: cleaning consists in applying a filling algorithm.
- Small Components: cleaning simply consists in removing corresponding faces.

# ContextCapture Master

## Reconstruction

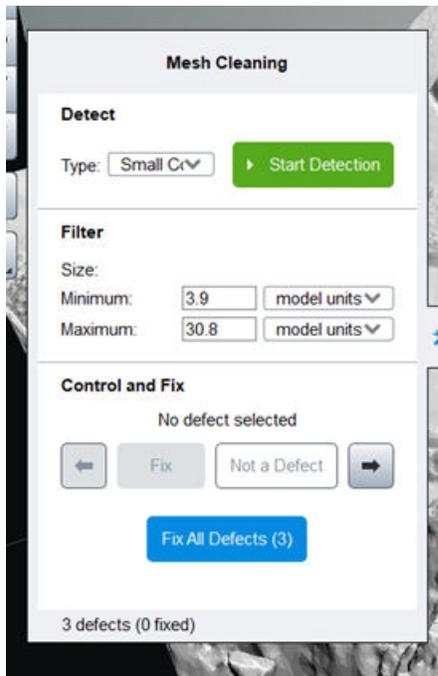


Figure 84: Mesh Cleaning panel

Mesh cleaning works in 3 steps:

1. Detect: Select the type of targeted defects and click on Start detection.
2. Filter: Filter the detected defects according to various criteria.
3. Control and fix: browse and review detected defects, and choose to fix or ignore them.

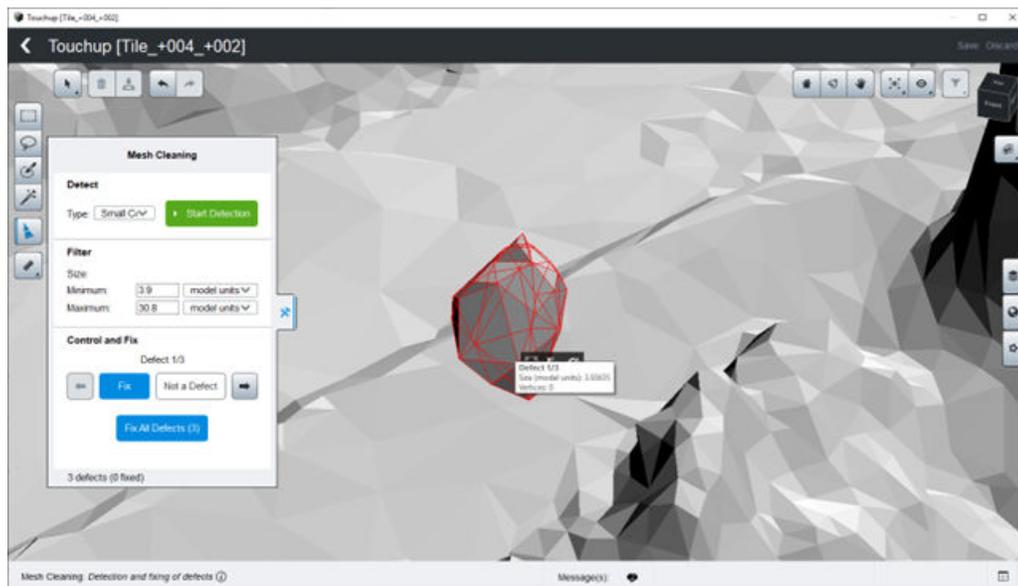


Figure 85: Example of small component detected with mesh cleaning tool

### Touchup with a 3rd party software

Fix the current reference 3D model with retouches created with 3rd party software.

To perform retouches, you must:

1. Produce tiles for retouching.
2. Apply tile corrections with some third-party software (Refer to Retouching).
3. Import retouched tiles.

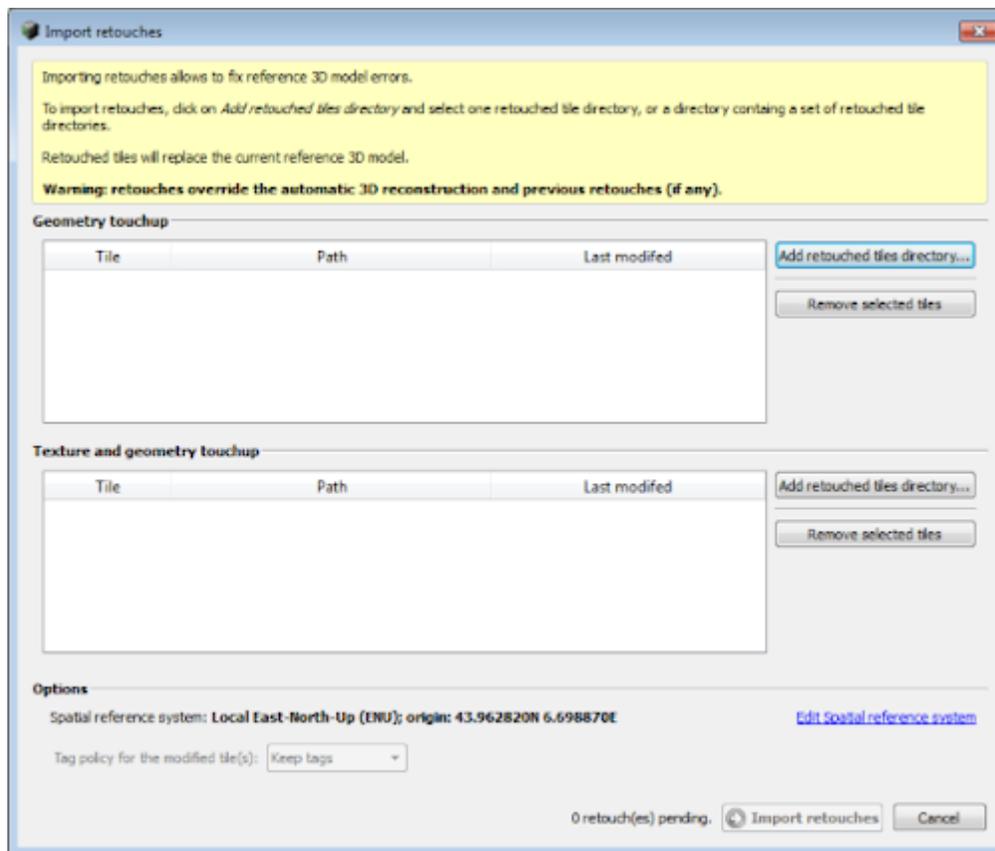


Figure 86: Import retouched tiles dialog

To import retouched tiles, click on Add retouched tiles directory in the selected retouch level section, and click on Import retouched tiles to proceed.

The following options are also proposed:

- Spatial reference system: for georeferenced projects you can choose to import retouched tiles produced in a custom spatial reference system.

When importing retouched tiles, this option is automatically set if a metadata file is detected.

Click on Edit Spatial reference system to select the appropriate reference system for your retouched dataset.

- Tag policy for modified tiles: a tag policy can be set to change tags of modified tiles.

# ContextCapture Master

## Reconstruction

⚠ For retouched tiles to be successfully imported, their tile directory and filename must respect the ContextCapture naming convention and must be the same as the ones of the production used for retouching.

Example of valid retouched tile path:

/Tile\_xxx\_yyy/ Tile\_xxx\_yyy.obj

See also Retouching.

## Reset

Clear a selection of the reference 3D model, so they are recomputed by later productions.

**Note:** Resetting all tiles and deleting all productions from the list allow you to re-edit all reconstruction settings including *Spatial framework* and *Processing settings*.

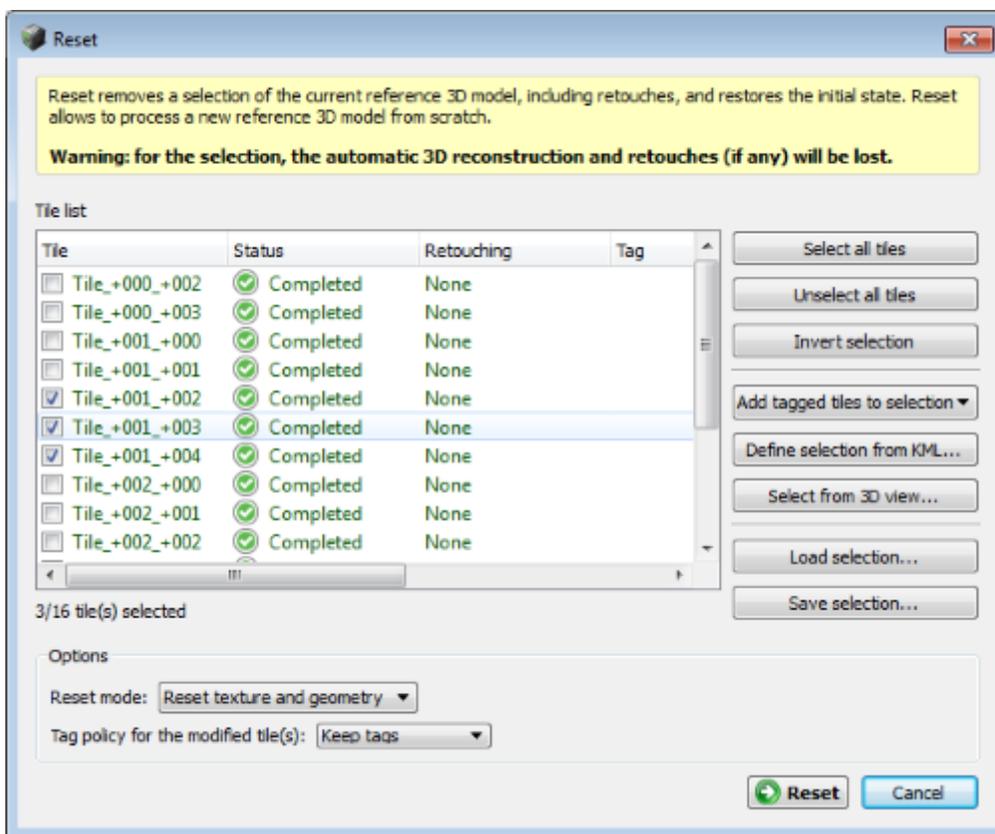


Figure 87: Reset tiles dialog

To reset tiles, select the list of tiles to reset and click on Reset.

See also [Tile selection](#) (on page 156).

The following options are proposed:

- Reset mode: reset can be applied on texture only or on both texture and geometry (default),
- Tag policy for modified tiles: a tag policy can be set to change tags of modified tiles.

## Inter-tile color equalization

*Apply inter-tile color equalization to limit color differences between tiles.*

**Note:** This option is only available when the reconstruction has been done using the Standard color equalization mode.

ContextCapture generates the 3D model texture from various input photos that may have been acquired in different lighting conditions.

In order to reduce radiometric differences between input photos in the 3D model texture, ContextCapture automatically proceeds to an advanced color equalization.

However, in the case of tiled model reconstruction, ContextCapture performs color equalization independently on each tile. This implies that tiled reconstructions include color differences that need to be fixed.

Once the reference 3D model with texture has been processed, an inter-tile color equalization can be computed to reduce radiometric differences between tiles.

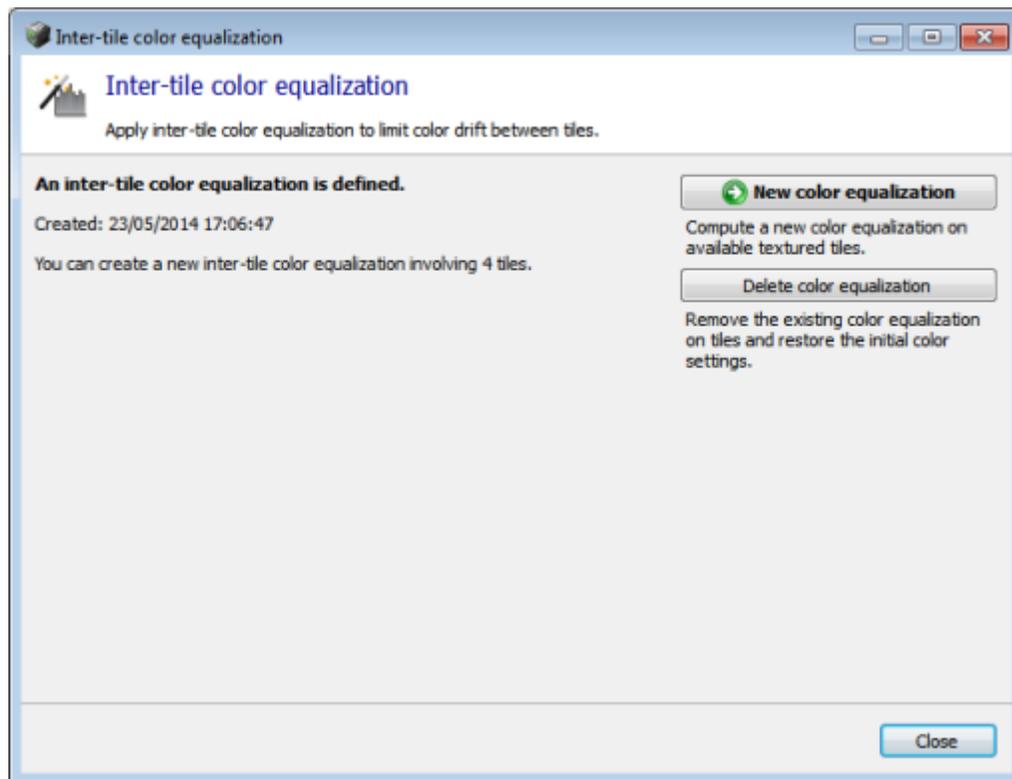


Figure 88: The inter-tile color equalization dialog

## New color equalization

*Compute a new color equalization on available textured tiles.*

## ContextCapture Master

### Reconstruction

---

The inter-tile color equalization algorithm considers all processed tiles with texture and computes a global equalization which will be used for later productions.

Color equalization resets the reference 3D model texture. The changes will be applied to any new production.

**⚠ Warning:** textured tiles processed before version 3 will have to be recomputed to benefit from the new color equalization feature. Reset the textures (Texture only mode) and perform a new production to upgrade them. See also [Reset](#) (on page 154).

**Note:** Tiles with texture imported from retouched files (ie. tiles with retouching level Texture and Geometry) are not taken into account in the color equalization computation.

### Delete color equalization

*Remove the existing color equalization and restore the initial color settings.*

Deleting color equalization also resets the reference 3D model texture. A new production is needed to restore the texture.



*Building facade reconstruction, without (left) and with (right) inter-tile color equalization: color differences between tiles are drastically reduced.*

### Tile selection

For a reconstruction using a tiling, tile selection may be needed for several operations in the workflow: to reset a set of tile, to produce a set of tiles, etc.

# ContextCapture Master

## Reconstruction

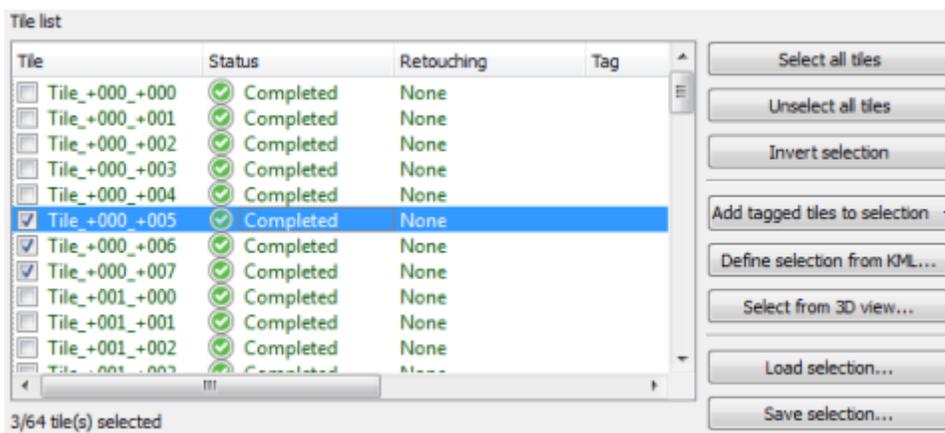


Figure 89: The tile selection area

Check or uncheck tiles to define the selection.

### Select all/Unselect all tiles/Invert selection

Basic management of the selection.

### Add tagged tiles to selection

If tags have been added to the reconstruction using the quality control interface, this command allows to use them to select tiles. See also [Quality control](#) (on page 71).

### Define selection from KML or DGN

For georeferenced reconstructions, the selection can be set from 2D polygons read from a KML or a DGN file. Any tile intersecting 2D polygons defined in the input file will be selected.

### Select from 3D view

You can select tiles interactively in a 3D view.

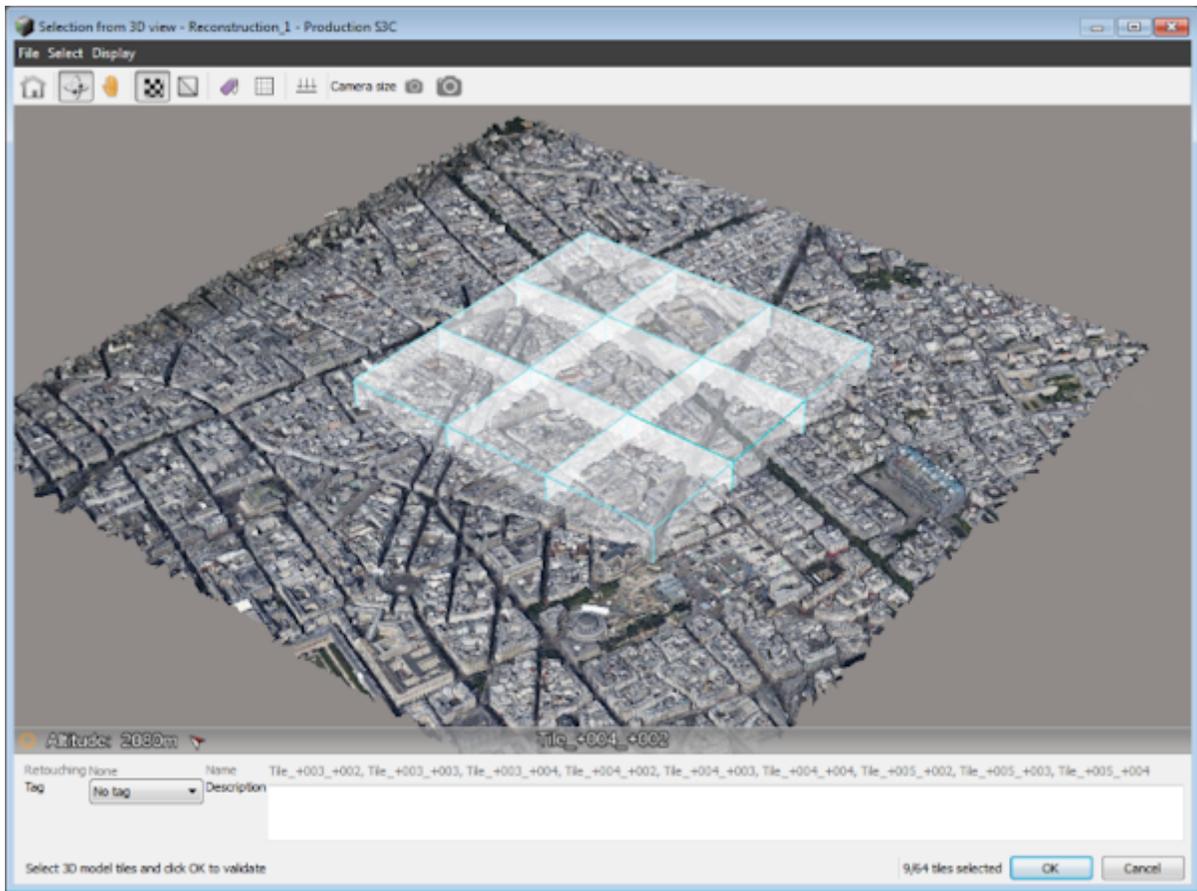


Figure 90: Selection from 3D view dialog

Click on the model to select or deselect tiles. Use SHIFT or CTRL to perform multi-selection.

Click on OK to validate the selection.

For more information, see also [Quality control](#) (on page 71).

## Load/save selection

Tile selection may be loaded from / saved to a basic text format.

Example of tile selection text file:

```
Tile_+000_+001_+001  
Tile_+001_+002_+000  
Tile_+001_+001_+002
```

If needed, tile selection files can easily be created with a third-party tool.

## Production

A Production item manages the generation of a model, with error feedback, progress monitoring and notifications about updates of the underlying reconstruction (example, retouching).

# ContextCapture Master

## Production

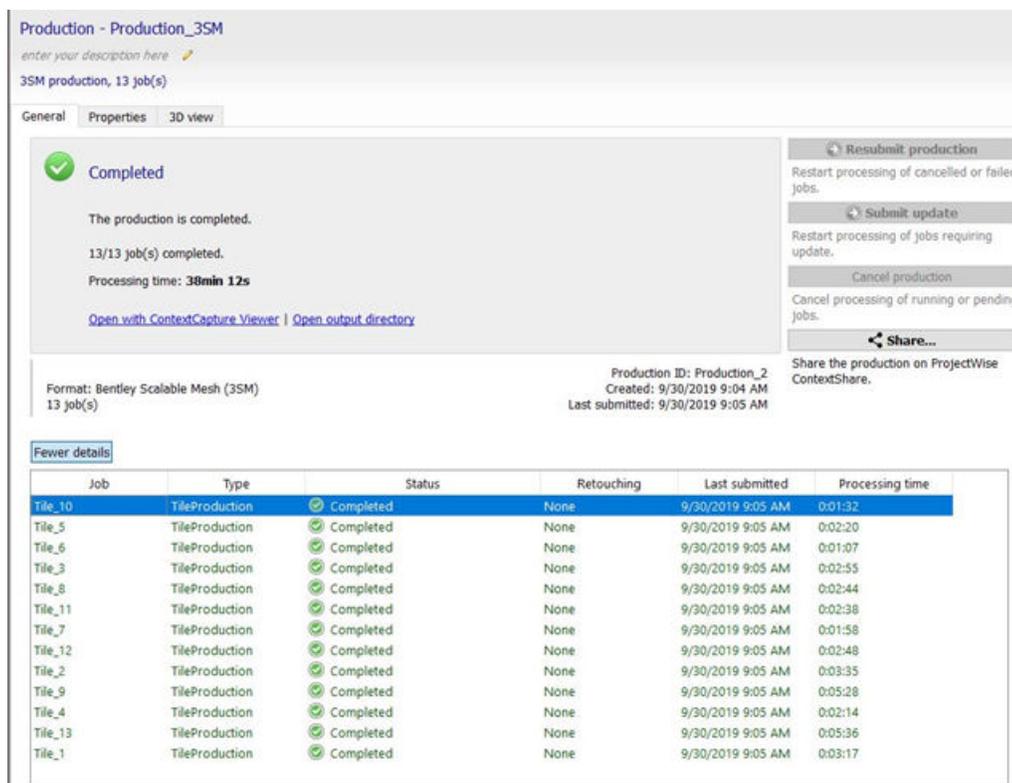


Figure 91: Production item interface

Productions are defined in ContextCapture Master, but are processed by ContextCapture Engine.

A production is defined by the following properties:

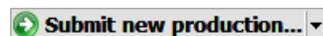
- Output format and options,
- Spatial reference system and extent,
- Destination.

Productions are used to process both the reconstruction reference model and to generate exported models in various formats: 3D meshes, point clouds, orthophotos/DSM.

Geometry constraints productions, available as Technology preview can automate geometry constraints creation on scene water surfaces to improve reconstruction.

## Creating a new production

In the Reconstruction tab, click on *Submit new production* to create a new production.



Name

Enter production name and description.

Purpose

Select the purpose of the production to submit:

# ContextCapture Master

## Production

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- 3D mesh: Produce a 3D model optimized for visualization and analysis in third-party software.
- 3D point cloud: Produce a colored point cloud for visualization and analysis in third-party software.
- Orthophoto/DSM: Produce interoperable raster layers for visualization and analysis in third party GIS/CAD software or image processing tools.
- 3D mesh for retouching: Produce a 3D model which can be edited in a third-party software then imported back into ContextCapture for later productions. An overlap between tiles is specially included. See also [Retouching](#) (on page 187).
- Reference 3D model only: Produce a 3D model which can be used only inside ContextCapture Master, for quality control and as cache for later productions. The reference 3D model is mandatory prior to process any orthophoto/DSM productions.
- Annotations: Execute ContextInsights technology leveraging artificial intelligence to automatically extract information from your reality data. This information will be delivered under various possible formats: image annotations, regular 3D-boxes, segmented meshes, point clouds or orthophotos.

Mesh and point cloud productions produce also the reference 3D model for internal use (reconstruction [Reference model](#) (on page 142)).

### Format and options

Choose the output format and corresponding options.

Proposed output formats and options depend on reconstruction properties and on the production purpose.

For more details about proposed formats, see [Output formats](#) (on page 161).

### Spatial reference system

For georeferenced reconstructions, choose the target coordinate system. See also [Spatial reference system](#) (on page 192).

Advanced options (according to format) : define the origin of the output coordinates in the production spatial reference system.

For a 3D mesh, by default, the automatic origin is set close to the model in order to avoid very large 3D model coordinates, causing loss of accuracy in some third-party software.

### Height offset

Some formats allow to define a height offset. The height offset can be used to ease the integration of the production with existing data (ie. separate the produced 3D mesh from an existing terrain model).

Please note that the height offset alters the production positioning.

### Extent

Define the production extent

For 3D mesh or point cloud production, select the tiles you want to produce (enabled only for reconstruction with several tiles).

Several selection tools are proposed (KML import, etc.). See also [Tile selection](#) (on page 156).

For Orthophoto/DSM, select the geographic extent to produce. A KML file can also be imported to define the extent.

### Destination

Choose the production location.

According to the format, select the output directory (select an empty directory) or the base url where to create the output production.

## Production processing

In the last page of the Production definition wizard, click on Submit to create the new production and submit the reconstruction job.



Create the new production and submit the reconstruction job.

Once the production is submitted, the production item is created and manages monitoring of the reconstruction processing.

The reconstruction is processed on ContextCapture Engine side. If there is no engine currently listening to the job queue, you must run an engine now or later to process the reconstruction

**Note:** You can continue working with ContextCapture Master or even close the interface while the production is pending or running: the job will remain in the queue and computation will be performed on engine side.

For more details about production monitoring, see [General](#) (on page 176).

## Output formats

Proposed output formats and options depend on the reconstruction properties and on the production purpose.

**Note:** On demand, Bentley Systems can develop exports to other 3D formats, for seamless integration with a large majority of third-party 3D visualization and processing software.

### 3D mesh

*Produce a 3D model optimized for visualization and analysis in third-party software.*

### Output formats

*Proposed 3D mesh formats are:*

**Note:** Refer to Software Editions table to verify what output formats are the supported specifically by your edition.

- 3MX format: an open format that we propose in order to facilitate the distribution of ContextCapture data. It can be used for:
  - Web publishing, by using our free ContextCapture Web Viewer, *you can publish or embed 3D models in your web site.*
  - Interoperability with other Bentley Systems products, such as ContextCapture Web Viewer and MicroStation.
  - Interoperability with third-party applications (3D GIS).

For more details about the 3MX format, see the format specifications in the ContextCapture installation directory.

# ContextCapture Master

## Production

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- Bentley Scalable Mesh (3SM): file format suitable for display, analysis and editing of large 3D meshes in Bentley design applications.

3SM 3D Tiles format can be directly displayed online in a 3D web viewer once published to ProjectWise ContextShare. See [Share on ProjectWise ContextShare](#) (on page 181).

- Smart3DCapture S3C (deprecated): Legacy format of ContextCapture, with compression, dynamic level-of-detail and paging.

S3C format is optimized for local or online navigation of entire reconstructions in real time with ContextCapture Viewer.

S3C scenes can be edited with ContextCapture [ContextCapture S3C Composer](#) (on page 205).

- OBJ wavefront format: A portable 3D format that can be loaded by most CAD and 3D software.

In this format, a single-level high resolution 3D mesh is proposed by default, but ContextCapture can generate level of detail if needed.

OBJ productions can also be published to Sketchfab. See [Publish to Sketchfab](#) (on page 186).

- Bentley DGN: Native 3D format of MicroStation and other Bentley CAD application.
- Collada DAE: Interchange file format for interactive 3D applications.
- Autodesk FBX: 3D exchange format for Autodesk applications.
- Stereolithography STL: Geometry format widely used for 3D printing (does not support texture).
- ESRI i3s scene database: ESRI Indexed 3d Scene format for ArcGIS Scene Service.

This format is used to stream 3D GIS data to ESRI mobile, web and desktop clients. It's supported from ArcGIS Server version 10.3.1, ArcGIS Pro version 1.1 and ArcGIS SceneViewer version 3.7/10.3.1.

It is recommended to produce with default options. Once the production is completed, *Create a scene package (SLPK file)* to get a single file easy to use with ESRI applications.

- Cesium 3D Tiles format, suitable for display in Cesium. [More information on Cesium](#).
- Google Earth KML: Hierarchical file format suited for real-time 3D display of very large datasets in *Google Earth*.
- OpenSceneGraph binary (OSGB): The native format of the open source [OpenSceneGraph](#) library, with dynamic level-of-detail and paging.

Best suited for SuperMap GIS.

- SuperMap S3M: Best suited for SuperMap GIS Software.
- OpenCities Planner LodTree: Interoperability format for OpenCities Planner, based on XML files and 3D models in Collada format.
- LOD tree export: a level-of-detail tree exchange format, based on XML files and 3D models in *Collada DAE* format.

Best suited for Eternix Blaze Terra, Agency9 CityPlanner, Skyline TerraBuilder, DIGINEXT VirtualGeo.

For more details about the *LOD tree export format*, see the format specifications in the ContextCapture installation directory ( ).

- SpacEyes3D Builder layer: SpacEyes3D Builder layer file based on OSGB format.

Best suited for SpacEyes3D Builder.

A generic SpacEyes3D Builder GVW project file is also created.

**Note:** City-scale 3D models are split into tiles when using ContextCapture, and our level-of-detail (LOD) structure is generated for each tile independently. This leads to an incomplete level-of-detail structure and low loading performance if the model contains a large number of tiles. As a solution to this problem, Bentley Systems

has developed a post-processing tool capable of creating the entire LOD structure. This tool is accessible through the LOD option 'Quadtree across tiles'.

## Options

*Enabled options for 3D mesh depend on the chosen format:*

- Include texture maps: include the texture or not (texture files and uv coordinates).
- Color source:
  - Visible colors: texture with photos with visible colors band.
  - Thermal: texture with photos with thermal band. Note: use 3D View or ContextCapture Viewer Measurements tool to display temperature values on the resulting mesh.
  - Resolution: texture with a color scale showing resolution of input data (either photos or point clouds).

**Note:** use 3D View or ContextCapture Viewer Measurements tool to display resolution values on the resulting mesh.

- Texture compression: choose the JPEG quality level (50%, 75%, 90%, 100%).
- Texture sharpening: enhance mesh texture by applying a sharp filter (enabled by default), this option can be disabled to keep the initial image sharpness.
- Level of detail (LOD): include levels of detail.

Type: type of LOD structure: simple levels, quadtree, octree, adaptive tree or Bing Maps Tiling System (only for reconstruction based on Bing Maps SRS).

Scope: Tile-wise (default) or Across tiles. See below.

Node size: depending on the application, a larger number of lighter LOD nodes may be more advantageous than a smaller number of heavier LOD nodes. This option allows to vary the size of LOD nodes, when using a quadtree, a octree or an adaptive tree.

- Skirt: the skirt is an additional border included around each geometry node and around each tile, to avoid cracks between the different parts of the mesh.

The skirt is not tangent to the 3D model: it lies in the boundary of the 3D region of the node, and it is oriented towards the interior of the 3D model. For example, the skirt between two side-by-side mesh nodes is composed of thin vertical strips. As the skirt length is given in pixels in input photos, it adapts to the local dataset resolution.

- Tile overlap: on reconstructions with tiling, an overlap between tiles is included to avoid cracks.

The overlap is given in meters (or units for non-georeferenced blocks): the overlap is uniform over the 3D model.

### About the LOD Scope option 'Across tiles'

The 3D models produced by ContextCapture are divided into tiles. In its current version, ContextCapture can generate a level-of-detail structure for each tile taken independently, but only the scope option 'Across tiles' will produce global level-of- detail structure (e.g., a quadtree) for an entire reconstruction.

Such a global LOD tree is desirable for real-time 3D rendering of a wide area without constraints on viewing altitude or tilt angle. This requires the manipulation of very low resolution versions of large parts of the model, the extreme case being one small 3D mesh to represent the entire model at very low resolution.

The LOD Scope option 'Across tiles' is based on the external command line tool "ExportUniqueMesh". See also ExportUniqueMesh.

# ContextCapture Master

## Production

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A production with LOD Scope option 'Across tiles' is made in two steps:

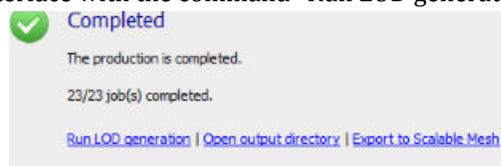
1. Production of reference 3D model.

This step is managed as usual by ContextCapture Engines.

2. LOD generation.

This step must be started manually once the first step is finished:

- Either from the production interface with the command "Run LOD generation",



In this case, the LOD generation happens on this computer.

**Note:** The LOD generation is not managed as usual jobs by ContextCapture Engine, but in a dedicated command line tool running in a command prompt.

- Or with the command script 'generateLOD.bat' available in the production's output directory.

In this case, the LOD generation can be started and processed from any computer, and even from several computers in parallel (on computers equipped with ContextCapture Engine).

## 3D point cloud

Produce a colored point cloud for visualization and analysis in third-party software.

## Output formats

*Proposed 3D point cloud formats are:*

- ASPRS LASer (LAS): public file format for interchange of 3-dimensional point cloud data.
- Pointools POD file format: Point-cloud format for use within Bentley Pointools and any MicroStation-based application.

**Note:** When using tiling, point clouds productions generate one file per tile. You can use the command Merge point clouds (available once ContextCapture production is complete) to create one unique point cloud file.

## Options

- Point sampling: sampling distance option (LAS format only).

If provided in pixels, the sampling distance is defined in pixels in input photos: the sampling depends on input photos resolution.

If provided in meters (or units for non-georeferenced blocks), the sampling distance is defined in the 3D coordinate space: the sampling is uniform over the 3D model.

- Compression: LAZ (for LAS format only).

If activated, produces zipped LAS with .laz file extension.

## Orthophoto/DSM

Produce interoperable raster layers for visualization and analysis in third-party GIS/CAD software or image processing tools.

### Note:

When using tiling, orthophoto/DSM productions generate one file per tile. You can use the command Merge orthophoto parts (available once ContextCapture production is complete) to create a single merged file for the orthophoto and for the DSM.

## DSM output formats

- TIFF/GeoTIFF: standard raster format with georeferencing information.
- ESRI ASCII raster/ASC: common ASCII format for grid exchange.
- XYZ: basic ASCII format with 3 columns, each line containing the X, Y and Z coordinates.

⚠ The reference 3D model geometry must be available to process DSM.

## Orthophoto output formats

- TIFF/GeoTIFF: standard raster format with georeferencing information.
- JPEG: standard compressed image format.
- KML Super-overlay: hierarchical image file format suited for real-time 3D display of very large orthophotos in *Google Earth*.

## Options

- Sampling distance: sampling distance option. Unit depends on the selected Spatial reference system.
- Maximum image part dimension (px): define the maximum tile size for the resulting raster file.
- Projection mode: define how the 2D data layer is processed from the 3D model (*Highest point* or *Lowest point*).
- Orthophoto/DSM: enable or disable the corresponding production.
- Color source:

*Optimized computation (visible colors)*: the best photos with visible colors band are selected according to the actual projection.

*Optimized computation (thermal)*: the best photos with thermal band are selected according to the actual projection.

*Reference 3D model visible color*: keep the internal reference 3D model with visible colors as is (mush faster).

*Reference 3D model (thermal)*: keep the internal reference 3D model with thermal band as is (mush faster).

- No data: pixel value or color representing no information.

⚠ The reference 3D model texture and geometry must be available to process orthophoto.

## Annotation Detectors

First thing to set is the annotation type. Then, unless for specific cases described hereafter, when a user imports his own source, annotations will result from a processing involving a detector. Detectors have been trained on

# ContextCapture Master

## Production

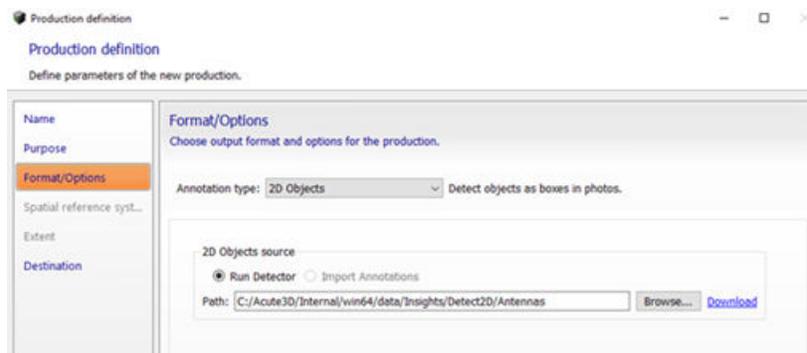
---

specific data and will be optimized/limited to run on the same kind of data (same nature, same environment, same data quality and resolution). Below are the various types of detector you will be able to use for annotation processing:

- Image - object detector
- Image - segmentation detector
- Pointcloud - segmentation detector
- Orthophoto detector
- Orthophoto + DSM detector

Detector types are designed to run on specific annotation types. Example, an orthophoto detector will not be applicable in a 3D-segmentation job. A series of detector is available on dedicated [Bentley Communities](#) webpage.

This page is accessible from ContextCapture Master Annotations page (Format/Options).

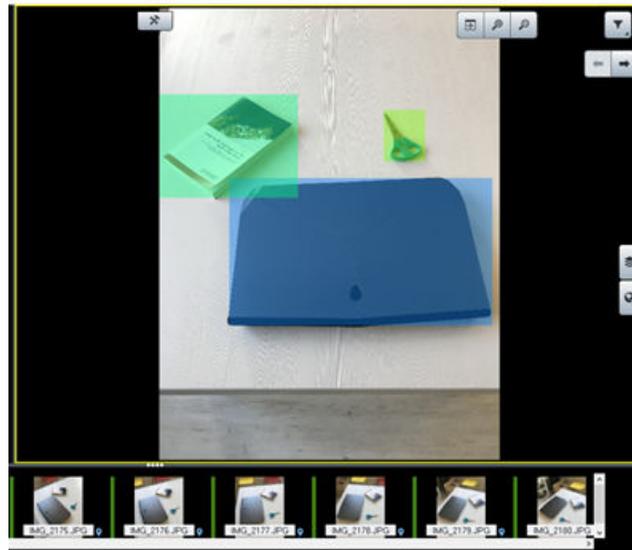


In case no detector is fitting your purpose, you are invited to submit a help request via your personal portal and describe your needs.

## Annotation type

### 2D Objects

This will detect objects in the images composing the block. Rectangular boxes will automatically be drawn around objects of interest in your images. These rectangular boxes can be viewed in Photo view and are recorded as a structured XML file in your production directory.



Objects of interest are the ones your detector has been trained to recognize. The path to this detector must be defined as below.

**Format/Options**  
Choose output format and options for the production.

Annotation type:  Detect objects as boxes in photos.

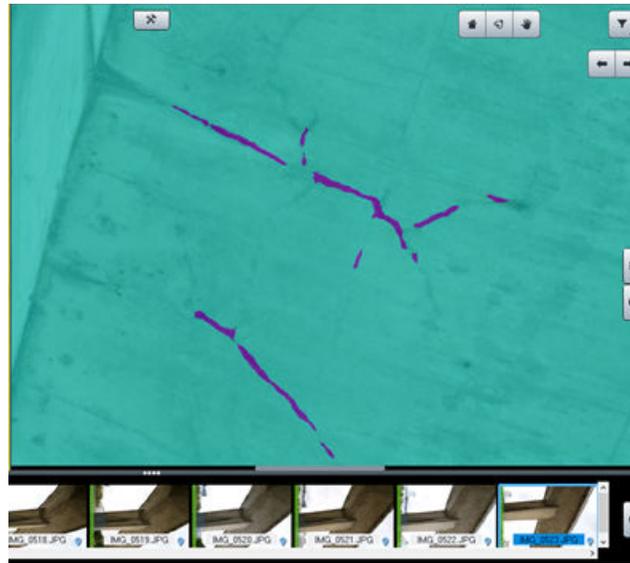
2D Objects source  
 Run Detector  Import Annotations

Path

Only image-object detectors can be used to run this type of job.

## 2D Segmentation

Each image of your dataset will be classified according to the detector you use. Classes of interest will be automatically extracted. It creates a PNG mask for each of your input images. Each pixel of this mask gets a class (unique pixel value) attributed. The series of masks is recorded in your production directory and linked to your block images by a single XML file. 2D Segmentation results can be reviewed in the Photos tab. Classes of interest are the ones defined during your detector's training.



Only image-segmentation detectors can be used for this purpose.

### 3D Objectss

It delivers regular 3D-objects (boxes) around elements of interest. Elements of interest are the ones defined by your detector or the 2D-annotations you chose to import. 3D objects are recorded in XML format and can be exported to DGN. Tie-points and point clouds (if available) can be used to better identify individual neighbor instances. The minimum number of views defines the amount of unique 2D-detection required so an annotation becomes a 3D object.

**Format/Options**  
Choose output format and options for the production.

Annotation type: **3D Objects** Turn 2D Objects into 3D boxes

2D Objects source

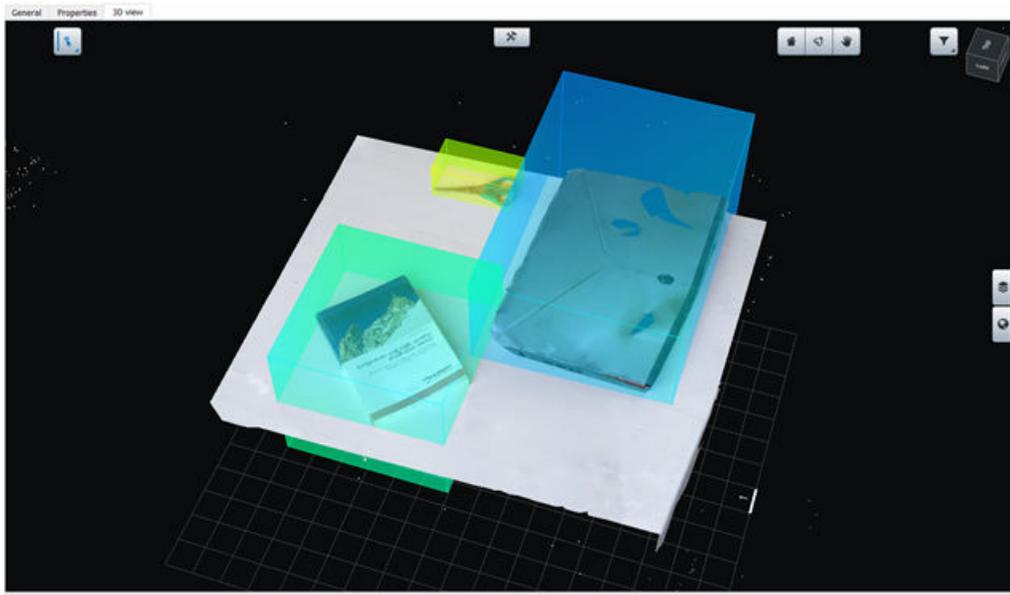
Run Detector  Import Annotations

Path:

Use tie points  Use point clouds  Export 3D boxes from Objects3D.xml into a DGN file

Minimum number of photos per 3D object:

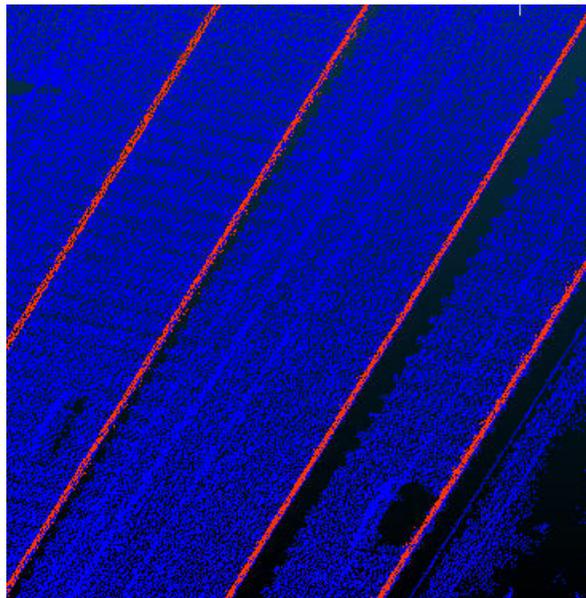
3D Objects can be displayed in the 3D-view after processing and overlay an existing mesh-production.



Only image-object detectors can be used for this purpose.

### 3D Segmentation

This will execute a classification of 3D point cloud. Either the one usually processed by ContextCapture Engine (Reconstruction Reference Mesh) or the one that was imported in the block (Block Point Clouds). The raw result for this annotation job is a classified pointcloud. This classification is obtained after executing an appropriate detector or after importing annotation in XML format. The resulting classified pointcloud can be exported in LAS format but cannot be displayed in ContextCapture Master 3DView. ContextCapture Editor can manage resulting classified LAS file.

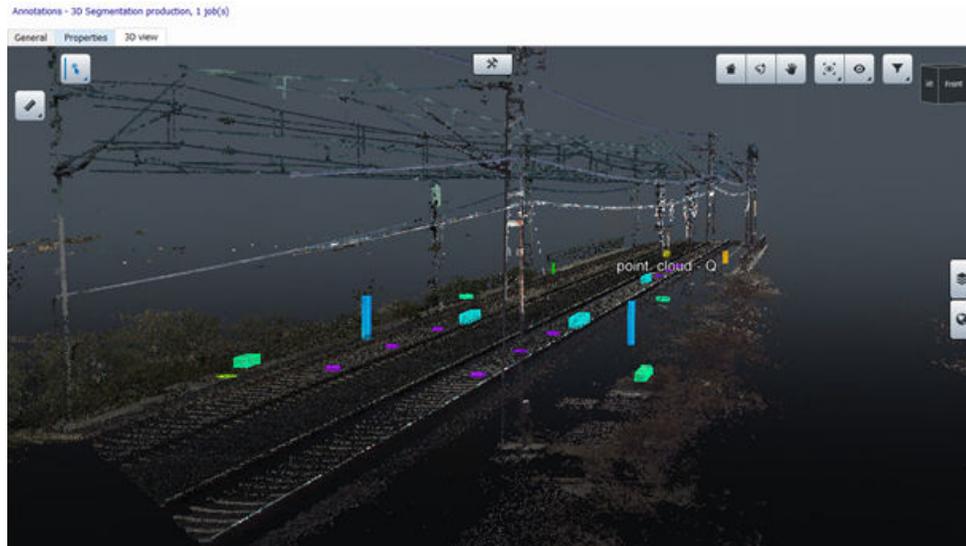


Out of 3D Segmentation, it is also possible to export individual 3D-objects. These 3D-objects are created based on 3D-pointcloud classification: neighbor points of same class derive 1 individual object. 3D individual objects

# ContextCapture Master

Production

are recorded as XML (see 3D Objects) and can be exported as DGN or OBJ files. 3D Objects derived from 3D Segmentation can be displayed in ContextCapture Master 3D-View.



The part of the classified pointcloud composing a 3D-object can also be exported as individual LAS files. Individual 3D-object identification can be improved by computing additional 2D-Objects detection or by importing 2D-Object annotation. In such case, resulting annotation is still a classified point cloud, possibly joined by individual 3D-objects that have been optimized using 2D-objects detection from images. Only image-segmentation and pointcloud-segmentation detectors can be used for this type of job. Image-object detector will also be usable but limited to an assistance role to optimize neighbor objects separation.

## Segmented orthophotos

The result of this job is a series of orthophotos (and DSM if selected) paired with a series of PNG masks. Orthophotos are traditional ContextCapture orthophotos and production settings are described in dedicated section. PNG masks are the result of a classification driven by the user-defined detector. PNG masks are geo-registered and overlaying RGB-orthophotos. Each pixel of the PNG masks has unique value corresponding to a class defined by the detector.



# ContextCapture Master

Production

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Detector must be defined at job submission stage. Following classification of PNG masks, a vectorization is possible as a Shapefile export. This transforms the class overlays in continuous polygon for optimized data management in GIS software.

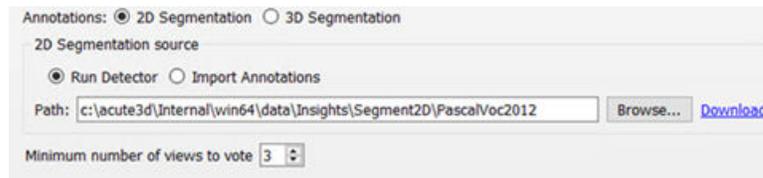


Only orthophoto and orthophoto+DSM detectors will be usable for this type of job. The role of DSM is to optimize classification according to the height of the target elements. An example is building footprints: their extraction will be more accurate if the detector has been trained and is submitted on an orthophoto+DSM case rather than a single orthophoto.

Segmented orthophotos cannot be viewed in ContextCapture Master 3DView.

## Segmented mesh

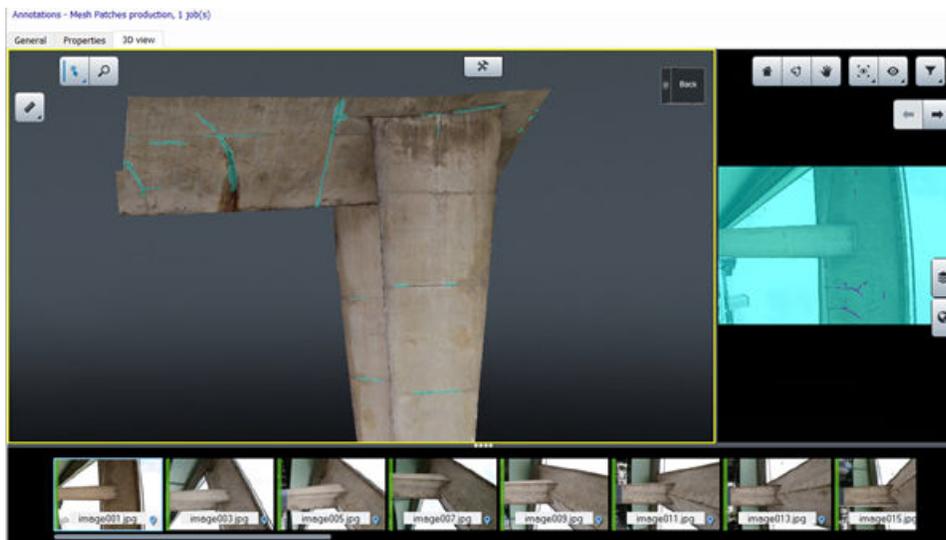
The result from segmented mesh is a traditional ContextCapture mesh for which the texture is fused with light color corresponding to detected elements. As a traditional mesh production, settings will be defined by the user: format, LOD, texture size, etc... and an additional setting will be defined for annotations.



Either a detector will be executed or an existing annotation will be imported as XML file to produce a mesh onboarding class information in its texture. Minimum views to vote define the amount of detected occurrences required to turn RGB-texture into classified texture.

# ContextCapture Master

Production



Segmented mesh can be viewed in ContextCapture Master 3DView (depending on the mesh format) as well as 2D Segmentation result if any.

Only image-segmentation and pointcloud-segmentation detectors can be used for this type of job.

## Mesh patches

Mesh patches will execute the same job as segmented mesh but will allow vectorization of all the areas of the mesh's texture considered as classified. Each segmented texture patch will be exported as an OBJ file. All material contained within these OBJ files can be exported as a pointcloud.



Only image-segmentation and pointcloud segmentation detectors can be used for this type of job. Mesh patches cannot be viewed in ContextCapture Master 3DView

## About LOD naming convention

3D mesh productions with LOD use a specific naming convention for node files according to tile name, level of detail resolution, and node path (for LOD trees).

For a node file "Tile\_+000\_+003\_L20\_000013.dae", the meaning is the following:

# ContextCapture Master

Production

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- Tile\_+000\_+003: tile name.
- L20: normalized level of detail which is related to ground resolution.

**Table 1: Level of detail and ground resolution correspondence table (sample)**

Level of detail	Ground resolution (meter/pixel or unit/pixel)
12	16
13	8
14	4
15	2
16	1
17	0.5
18	0.25
19	0.125
20	0.0625

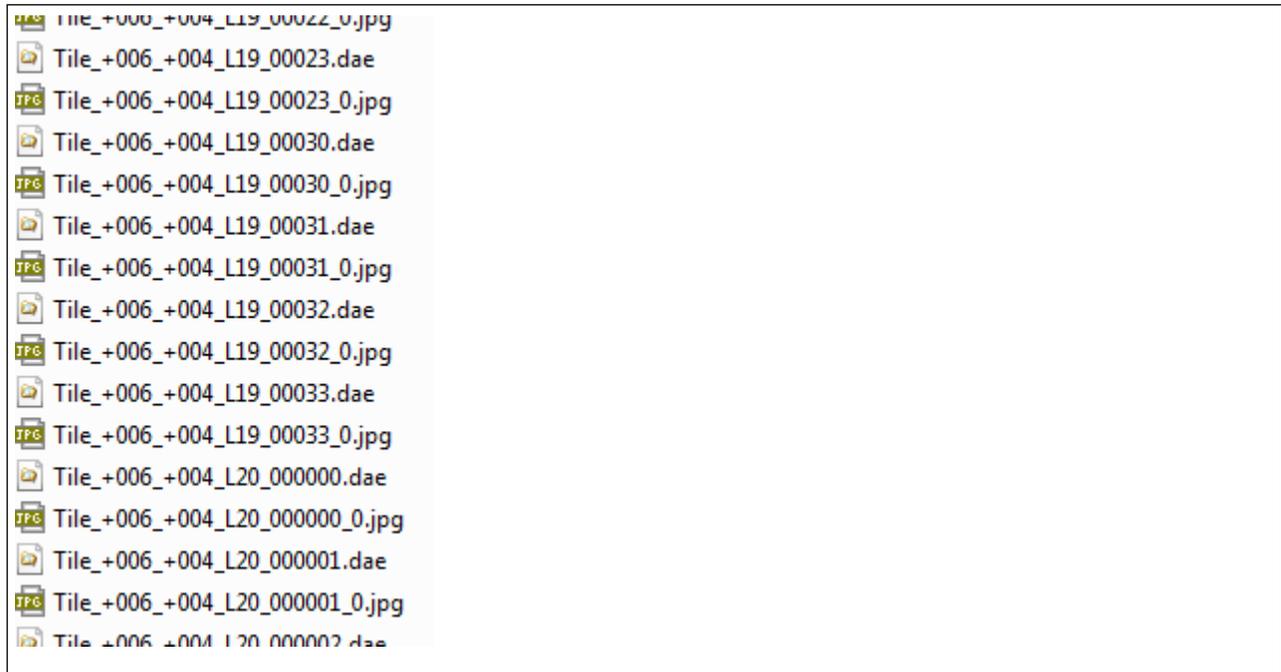
- 000013: optional node path, only included for LOD tree.

Each digit of the node path corresponds to a child index (zero-based) in the tree. For quadtree and octree productions, the child index unambiguously indicates the quadrant/octant of the child node.

**Table 2: Example of node files for a production with LOD of type simple levels**

 Tile_+006_+004_L14.mtl
 Tile_+006_+004_L14.obj
 Tile_+006_+004_L14_0.jpg
 Tile_+006_+004_L15.mtl
 Tile_+006_+004_L15.obj
 Tile_+006_+004_L15_0.jpg
 Tile_+006_+004_L16.mtl
 Tile_+006_+004_L16.obj
 Tile_+006_+004_L16_0.jpg
 Tile_+006_+004_L17.mtl
 Tile_+006_+004_L17.obj
 Tile_+006_+004_L17_0.jpg
 Tile_+006_+004_L18.mtl
 Tile_+006_+004_L18.obj
 Tile_+006_+004_L18_0.jpg
 Tile_+006_+004_L19.mtl
 Tile_+006_+004_L19.obj
 Tile_+006_+004_L19_0.jpg
 Tile_+006_+004_L20.mtl
 Tile_+006_+004_L20.obj
 Tile_+006_+004_L20_0.jpg
 Tile_+006_+004_L21.mtl
 Tile_+006_+004_L21.obj
 Tile_+006_+004_L21_0.jpg

**Table 3: Example of node files for a production with LOD of type quadtree**



## Extent

Defines the area of the production.

The extent defines a clipping region for the production.

By default, the production extent covers the whole region-of-interest of the reconstruction.

The extent can be defined roughly by editing production bounds.

An extruded polygon can be used to define the area more precisely from a DGN or from a KML file (if the reconstruction is georeferenced). Click on the button Import from polygon to specify the region of interest from a KML or a DGN file. The polygon file only defines a 2D polygon: top and bottom height can be defined from the interface.

For mesh productions using a tiling, you can limit the production to a subset of tiles. By default, ContextCapture will select all the tiles necessary to cover the given extent.

## Share

Most output formats can be published to ProjectWise ContextShare. See Publish to ProjectWise ContextShare.

## Geometry constraints/Surface water detection (Technology preview)

# ContextCapture Master

## Production

This technology preview involves advanced AI algorithms to automate detection of water surfaces which can be used as geometry constraints for reconstruction.

The process requires photos, georeferenced positioning level, regular planar grid and AI compatible GPU.

The process generates 3D meshes in OBJ format that can be used as geometry constraints for reconstruction.

## Process on the cloud

Project processing can run on the cloud with ContextCapture cloud processing service.

A ContextCapture Cloud Processing Console project is created from the block contents to allow cloud processing submission.

Learn more about cloud [ContextCapture cloud processing service](#) (on page 180).

## General

The production General tab manages the production processing.

Format: ContextCapture 3MX  
13 job(s)

Production ID: Production\_3  
Created: 10/1/2019 9:44 AM  
Last submitted: 10/1/2019 9:44 AM

Job	Type	Status	Retouching	Last submitted	Processing time
Tile_10	TileProduction	Completed	None	10/1/2019 9:44 AM	0:01:36
Tile_5	TileProduction	Completed	None	10/1/2019 9:44 AM	0:02:26
Tile_6	TileProduction	Completed	None	10/1/2019 9:44 AM	0:01:06
Tile_3	TileProduction	Running (73%)	None	10/1/2019 9:44 AM	0:00:12
Tile_8	TileProduction	Pending	None	10/1/2019 9:44 AM	Unknown
Tile_11	TileProduction	Pending	None	10/1/2019 9:44 AM	Unknown
Tile_7	TileProduction	Pending	None	10/1/2019 9:44 AM	Unknown
Tile_12	TileProduction	Pending	None	10/1/2019 9:44 AM	Unknown
Tile_2	TileProduction	Pending	None	10/1/2019 9:44 AM	Unknown
Tile_9	TileProduction	Pending	None	10/1/2019 9:44 AM	Unknown
Tile_4	TileProduction	Pending	None	10/1/2019 9:44 AM	Unknown
Tile_13	TileProduction	Pending	None	10/1/2019 9:44 AM	Unknown
Tile_1	TileProduction	Pending	None	10/1/2019 9:44 AM	Unknown

Figure 92: Production General tab

## Dashboard

The dashboard allows to monitor production processing.



Restart processing of cancelled or failed jobs.

# ContextCapture Master

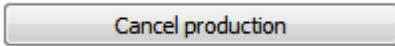
Production



Restart processing of jobs requiring update.

The existing output directory will be overwritten.

**⚠** When the reference 3D model is updated with retouched or reset tiles, existing productions are notified and corresponding jobs are marked as requiring update.



Cancel processing or running or pending tiles.



Share the production on ProjectWise ContextShare. See Web publishing.

## Details

The production is performed job by job, click on More details to get details about the production status of jobs and to monitor each job individually.

Production processing can be controlled at job level from the job context menu.

Tile	Status	Retouching	Tag	Description
le_+000_+000	Completed	None		
le_+002_+000	Completed			
le_+003_+000	Completed			
le_+002_+001	Completed			
le_+003_+001	Completed			
le_+002_+002	Completed			

A context menu is open over the table, listing the following options: "Open visible colors model with ContextCapture Viewer", "Reset", "Reset visible colors texture only", and "Reset thermal texture only".

Figure 93: Production job context menu

## Troubleshooting

If the production of a job fails, our technical support team may ask you to export the log file of the job; you can export it from the job context menu in the job table: choose Export log file for technical support.

**Note:** The log file is only dedicated to our technical support team and is not human readable.

## Production result

Produced job results appear in the selected *output directory* as soon as they are processed.

Click on the link *Open output directory* to open the production folder in *Windows Explorer*.

**Note:** For productions in 3MX format, you can display the output production with ContextCapture Viewer by double clicking the 3MX file.

# ContextCapture Master

Production

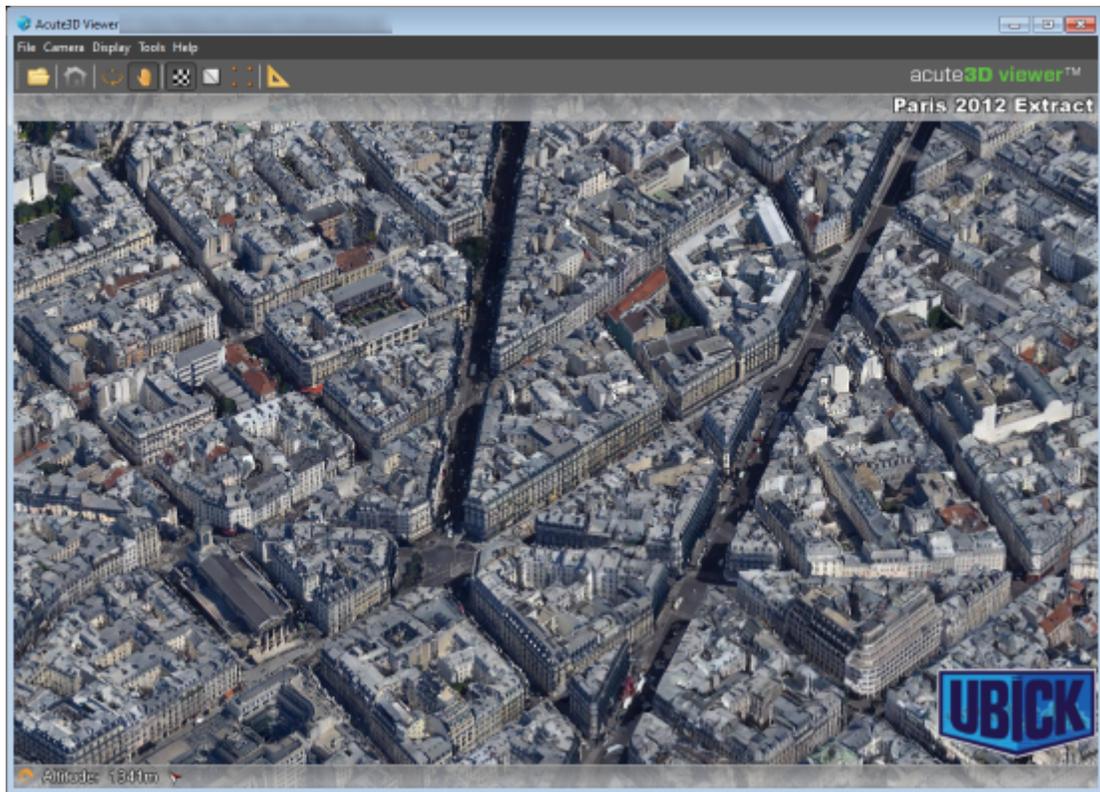


Figure 94: Example of production result displayed with ContextCapture Viewer

## Properties

The Properties tab provides a summary of main production settings.

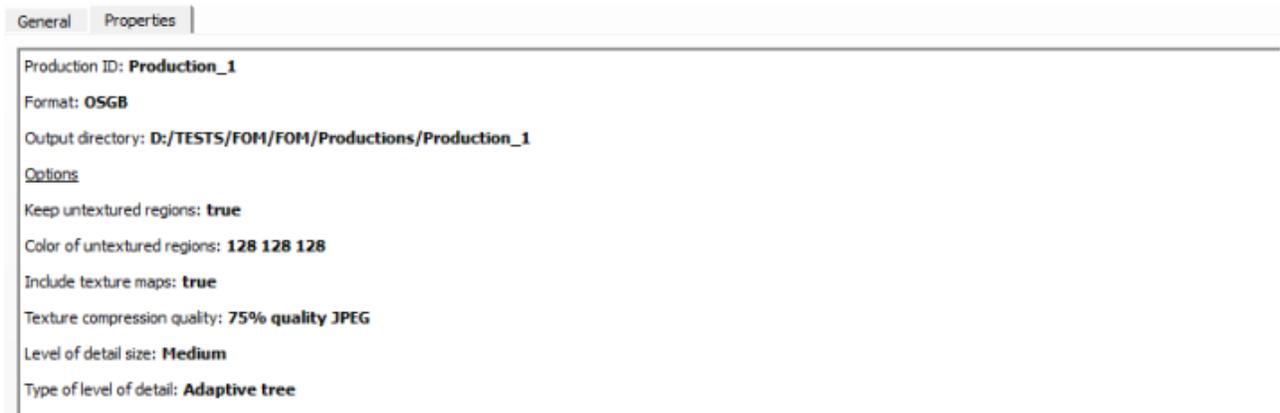


Figure 95: Production Properties tab

## 3D View

# ContextCapture Master

## Job Queue Monitor

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The 3D view tab allows the user to visualize and control production output.

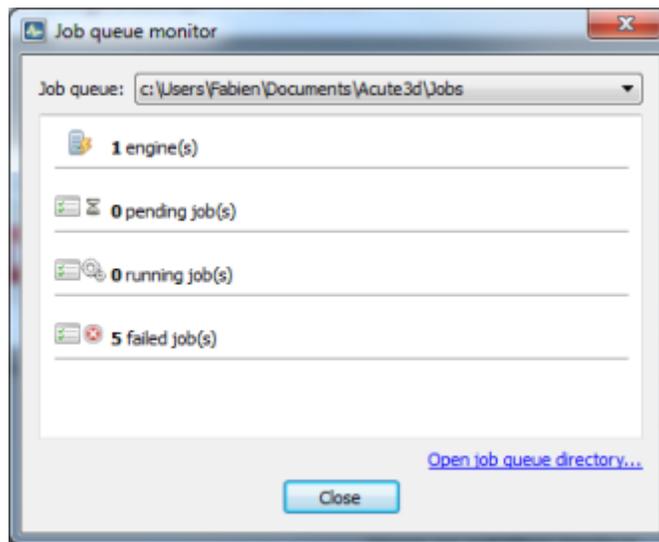
## Job Queue Monitor

The Job queue monitor is an independent panel displaying the current status of the job queue.



*Job queue monitor*

Open the Job queue monitor panel.



*Figure 96: The Job queue monitor panel*

## Job queue selection

If a Job queue different from the default one has been set for the active project, the monitor allows to shift from a Job queue to another: in the Job queue combo-box, select the Job queue you want to display.

## Job queue status

The monitor displays a summary of the Job queue status:

- Engine(s): displays the number of engines currently listening to the Job queue.
- Pending job(s): displays the numbers of jobs which are waiting to be processed.
- Running job(s): displays the number of jobs being currently processed by an engine.
- Failed job(s): displays the number of jobs that have been rejected by an engine after an error.

## Job queue management

Jobs are managed using database files in the job queue directory.

The job queue cannot be managed directly, it can be done:

## ContextCapture Master

ContextCapture cloud processing service

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- Per project from ContextCaptureMaster interface: aerotriangulation jobs and productions jobs can be simply monitored from the user interface.
- From ContextCapture Master Kernel SDK: the SDK allows to monitor the job queue programmatically either per project, either globally with the dedicated Job Queue monitoring API.

Click on *Open job queue directory* to access the Job queue directory.

## ContextCapture cloud processing service

ContextCapture can process aerotriangulation and 3D reconstruction jobs using ContextCapture Engine, but at any time processing can also run on the cloud using ContextCapture cloud processing service.

From a block or from a reconstruction, simply click on the Submit button and choose Process on the cloud to continuerun processing withon ContextCapture cloud processing service.

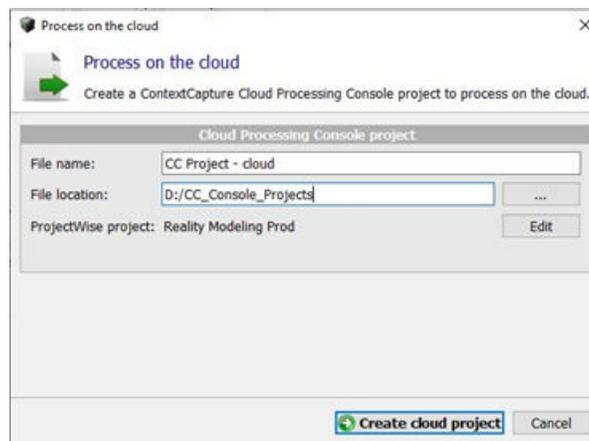
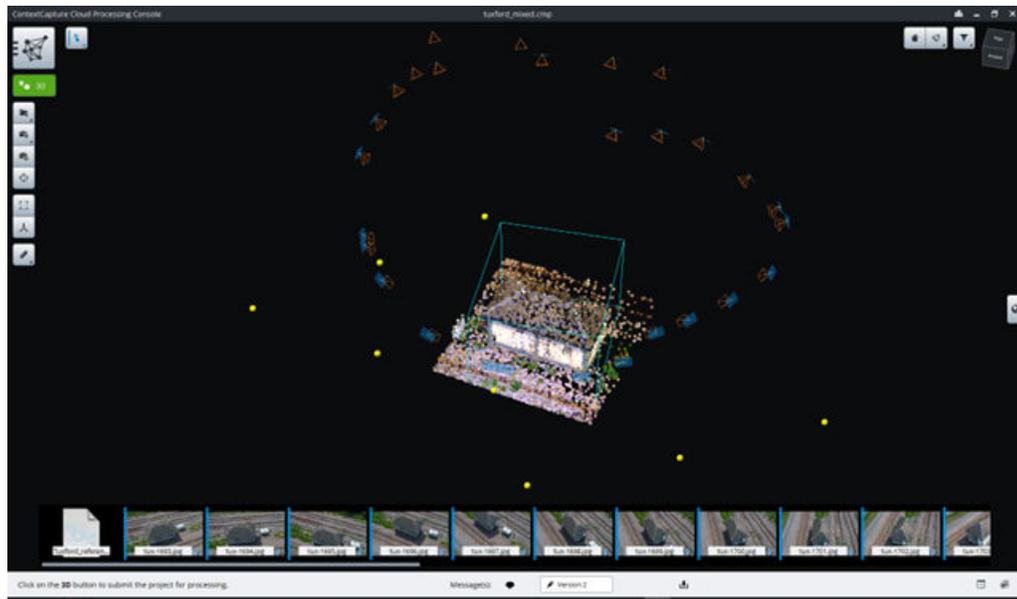


Figure 97: Process on the cloud dialog

A ContextCapture Cloud Processing Console project is created from the project contents to allow cloud processing submission.



*Figure 98: ContextCapture Cloud Processing Console interface.*

Please consult ContextCapture Cloud Processing Console user manual to learn more about cloud processing.

## Web publishing

ContextCapture users have several options for publishing their original 3D content on the Internet.

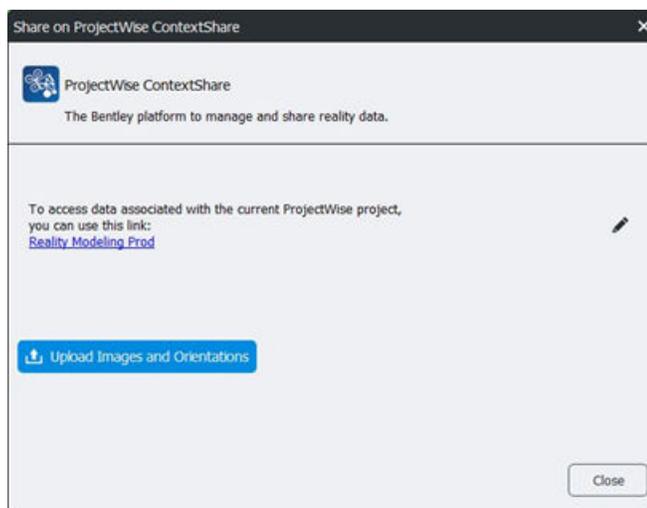
### Share on ProjectWise ContextShare

ProjectWise ContextShare is the Bentley platform to publish, manage and share reality data. From ContextCapture, you can directly share images, scans and orientations, or productions. Reality data can be shared and managed after being uploaded to ProjectWise ContextShare:

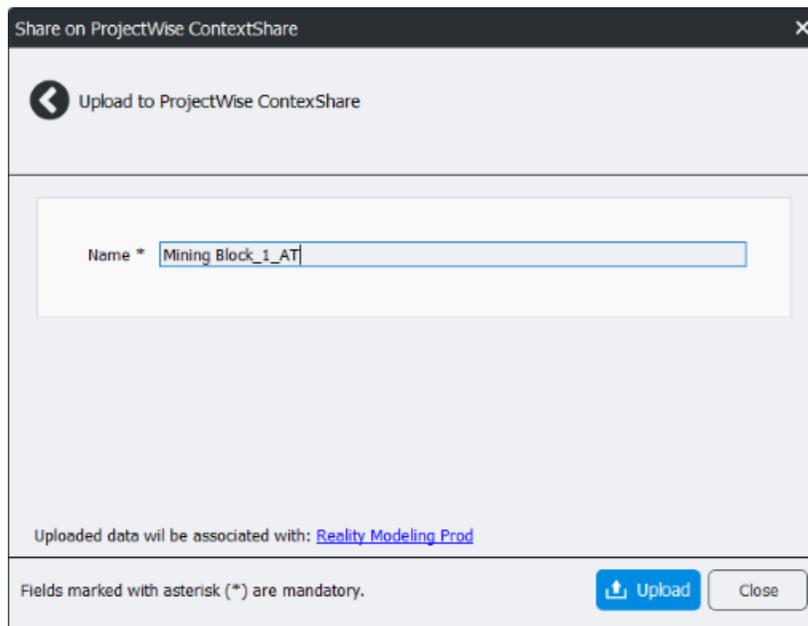
1. From the block or from the production General tab, click on Share.

# ContextCapture Master

Web publishing



2. Associate a ProjectWise project if necessary not done yet.
3. Click the Upload button to start uploading data.



4. Define publication name.
5. Click on Upload.

The upload time can significantly vary, depending on the size of the block and on your internet bandwidth. Typical upload time is about a few minutes.

**⚠** Internet access is required for ProjectWise ContextShare uploads. You may have to define proxy settings of your internet connection. See Installation (on page 9), Licensing (on page 10), and Configuration (on page 9).

Once reality data is uploaded, it is online and you can manage it from the CONNECT portal.

To access published data, note that users must be signed-in under a Bentley CONNECT account with the right permissions.

## Publish with ContextCapture Web Viewer

ContextCapture Web Viewer is made to publish or embed on a website the 3D models produced in 3MX format with ContextCapture .

3MX productions can be visualized online in any web site using our free [ContextCapture Web Viewer](#) (on page 202). Our web viewer is a cross-platform WebGL 3D viewer, suitable for desktops, tablets and smartphones. It works within any browser supporting WebGL, without the use of plug-ins, and it can be embedded easily in any web page. You only need to upload your 3MX productions to your Web server (or to an online file storage web service / content delivery network such as Azure Blob or Amazon S3/CloudFront) to publish or embed your 3D models in your own web site.

For web publishing your 3D model in 3MX format, the following method is the simplest:

- Step 1: Produce your model in the 3MX format, with the WebGL ready option checked.
- Step 2: Upload the entire Production folder (including both the Scene and App sub-folders) to your Web server.
- Step 3: Access the model by the address `http://your_server/your_production/App/index.html`.

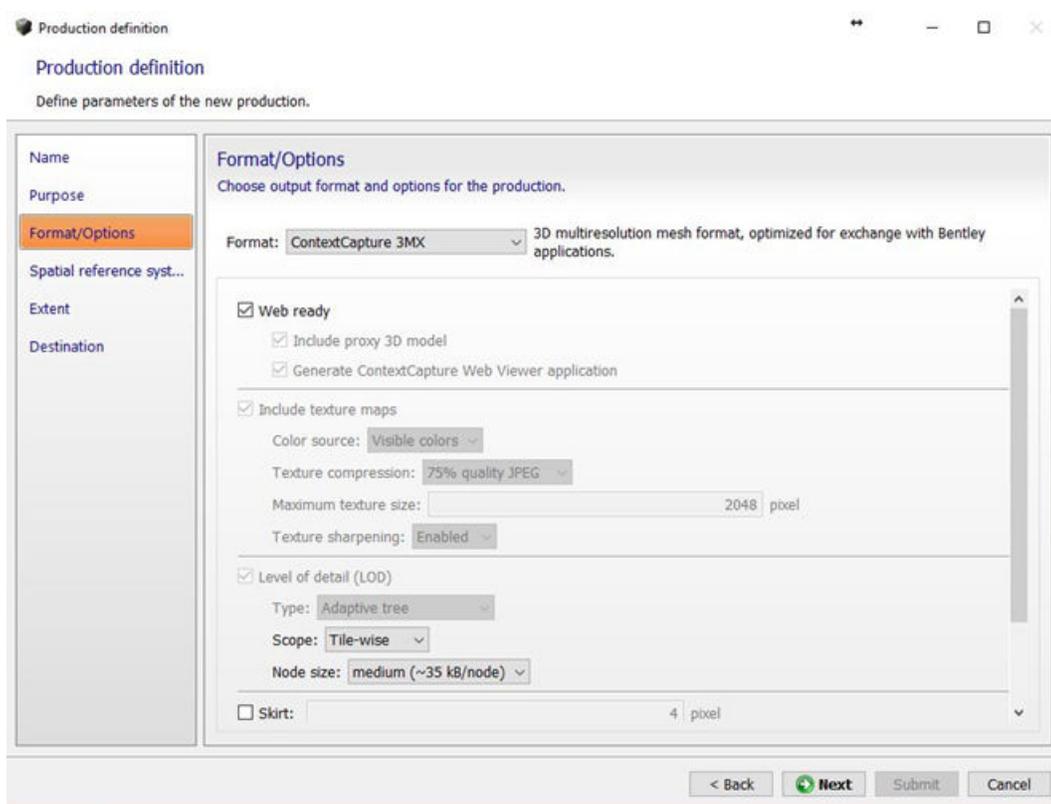


Figure 99: Producing the 3MX format for web publishing.

Online file storage web services / content delivery networks such as Azure Blob/CDN or Amazon S3/CloudFront are also supported.

You can also customize your model visualization, by inserting your logo, for example, or by adding a model description that viewers will be able to see.

## ContextCapture Master

Web publishing

The web visualization can be configured simply by editing the master 3MX file with a text editor.

For more details, see Chapter 15, [3MX Web Deployment](#) (on page 229).

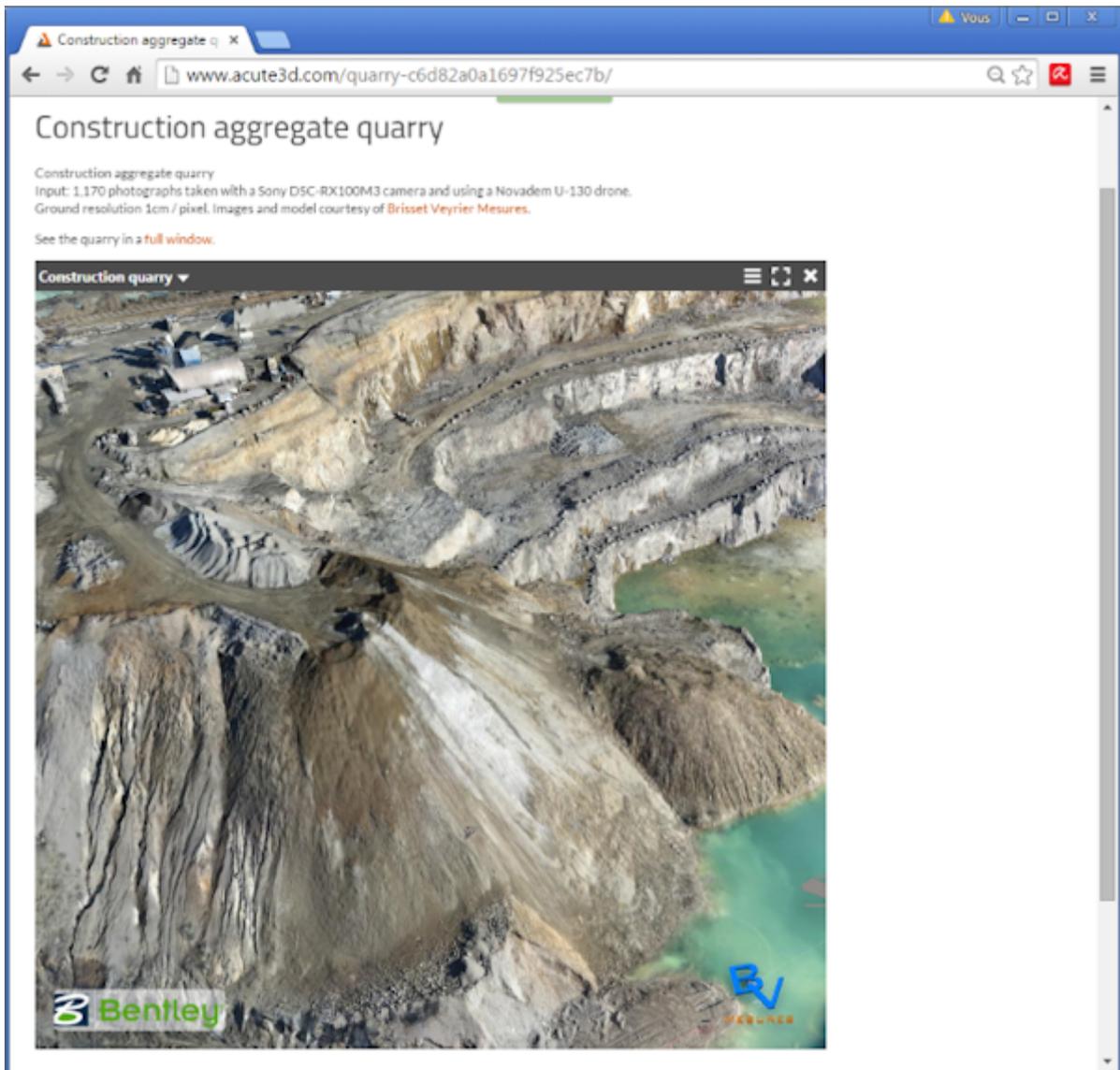


Figure 100: Example of a 3MX production embedded in a web page with ContextCapture Web Viewer. Customized scene settings are used to setup the logo and the description.

**Note:** City-scale 3D models are split into tiles when using ContextCapture, and the level-of-detail (LOD) structure used by the 3MX format is generated for each tile independently. This leads to an incomplete level-of-detail structure and low loading performance if the model contains a large number of tiles. As this is especially visible in a web environment, BentleySystems has developed a post-processing tool capable of creating the entire LOD structure. This tool, called ExportUniqueMesh, is currently in its beta version. To find out more about ExportUniqueMesh, please refer to the documentation included in your doc folder:

### Publish to Cesium or ContextCapture Web Viewer 2.0

ContextCapture can generate 3D models with level-of-detail in the Cesium 3D Tiles format, for streaming and display in Cesium web applications. Optionally, ContextCapture can generate a base Cesium or ContextCapture Web Viewer 2.0 application which can be published directly to the Web. Cesium is purely client-based, so the Cesium 3D Tiles data and the Cesium application can be hosted on a static Web server.

Online file storage web services/content delivery networks such as Azure Blobs/CDN or Amazon S3/CloudFront are also supported.

You can publish a 3D model to a Cesium or ContextCapture Web Viewer 2.0 application with the following steps:

1. Produce your model in the Cesium 3D Tiles format, with the Generate base Cesium application (or ContextCapture Web Viewer 2.0 application) option checked. For Cesium application, obtain a Bing Maps API key at <https://www.bingmapsportal.com> to be able to use Bing Maps as a source of imagery for the Cesium globe and enter the Bing Maps API key at the top of the app\_cesium/main.js file of the production. For ContextCapture Web Viewer 2.0 application this step is not necessary.
2. Upload the entire Production folder (including both the Scene and App sub-folders) to your Web server.
3. Access the Cesium app at the address [http://your\\_server/your\\_production/App/index.html](http://your_server/your_production/App/index.html).

Optionally, before steps 3 and 4, you can customize the base application.

- For Cesium application, in a few lines of Javascript, you can add your credits/logo, mix the 3D model generated by ContextCapture with other 3D models, raster or vector GIS data. Please refer to the Cesium tutorials to get started.
- For ContextCapture Web Viewer 2.0 application, optionally before step 3, you can edit the configuration file resources/config.json to change basic application settings:
  - unit: unit system for measurements, metric or imperial.
  - title: web page title.

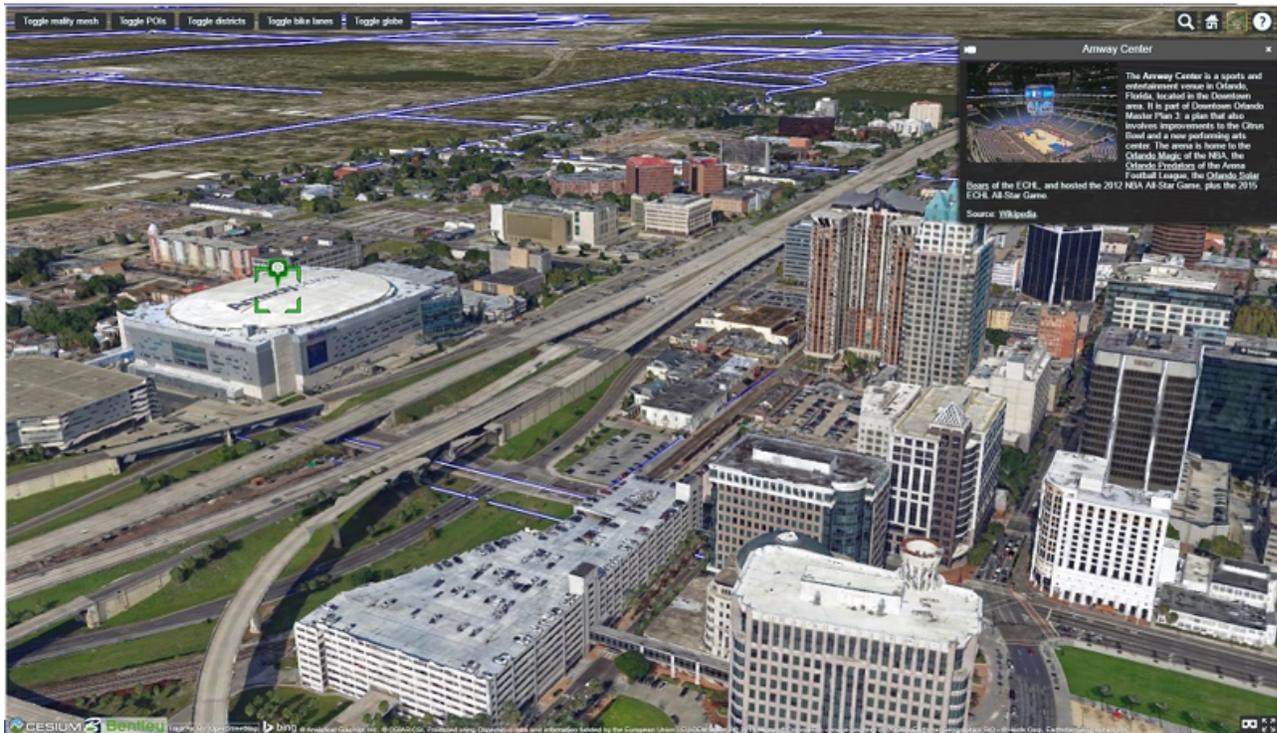


Figure 101: Example of 3D model of Orlando published in Cesium 3D Tiles format to a Cesium Web application. It took about a hundred lines of JavaScript code to add vector and POI data to the Cesium base application generated by ContextCapture .

## Publish to Sketchfab

Sketchfab is a platform to publish, share and embed 3D models, you can sign up for free on [sketchfab.com](https://sketchfab.com).

To publish to Sketchfab, you must first produce your reconstruction in OBJ format.

OBJ productions made of several tiles or with LOD are not supported.

1. From the OBJ production *General* tab, click on *Publish to Sketchfab*.



Figure 102: OBJ production General tab.

## ContextCapture Master

### Retouching

2. Define your Sketchfab model properties, and your API token.

You can find your API token in your Sketchfab registration confirmation email, or in your Sketchfab settings.

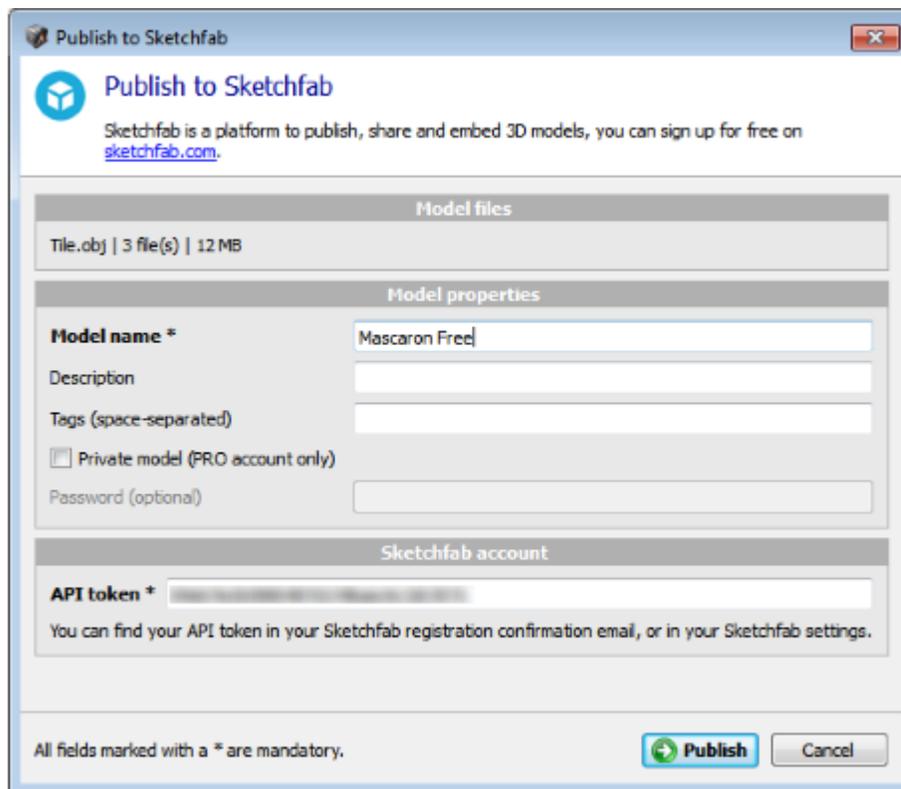


Figure 103: Publish to Sketchfab dialog

3. Click on *Publish* to upload your model to Sketchfab.

The publishing time can significantly vary, depending on the size of the 3D model and on your internet bandwidth. The typical publishing time is of a few minutes.

 Internet access is required for publishing to Sketchfab. You may have to define proxy settings of your internet connection. See [Installation](#) (on page 10).

Once your model is published, it is online and you can manage it from the [Sketchfab website](#).

**Note:** For a better result, we recommend to set the scene Shading to Shadeless from Sketchfab 3D settings.

## Retouching

In some cases, the output 3D models may include misconstructions that need to be fixed (unseen areas, reflective parts, water area...).

Output 3D models may be fixed in a third party software at the end of, or during the ContextCapture process by modifying the reconstruction reference 3D model.

Retouching the ContextCapture reconstruction reference 3D model allows to benefit from ContextCapture automatic texturing and/or output formats.

Important notice: Retouching process may be avoided by managing [Geometry constraints](#) (on page 141).

## Touch up workflow

In most cases, the advised process is the following:

### 1. Identify the tiles where retouching is needed.

You must first produce the model in 3MX format and visualize it in ContextCapture Viewer. When defects are detected, select the corresponding tiles (*Menu > Tools > Tile selection*) and export the list of tiles to retouch in a .TXT file.

### 2. Create production for retouching.

Submit a new production with the purpose 3D model for retouching from the active reconstruction:

- *Name*: as you want.
- *Description*: optional.
- *Selection*:
  1. Manually select the desired tiles by checking the corresponding boxes.
  2. You can alternately load a tile selection file including the list of tiles with the Load selection button.
  3. Or you can automatically select tiles by loading a KML file with the Define selection from KML button. All tiles included in / crossed by the polygon described in the KML will be selected.
- *Purpose*: choose 3D mesh for retouching.
- *Format*: DGN (default) or OBJ wavefront (default).
- *Options*: include or not the texture (it is recommended to include texture as it helps interpretation during retouching).

Optional: change the color of non-textured faces.
- *Directory*: choose directory where files will be generated (see below).

See also [Production](#) (on page 158).

 You should preserve the file structure of the production to be able to later import retouched tiles into ContextCapture Master.

### 3. [Optional] Save a copy of the reference 3D model before retouching.

If you want to keep track of all different stages of the retouching process, for each tile, make a copy of the directory which contains the tile ready for retouching:

- Keep this copy as the original tile automatically generated by ContextCapture .
- Use the main version for saving the changes made to the tile during retouching. In case of multiple tiles, this procedure can of course be applied to the parent directory containing all tiles.

### 4. Edit tiles with a 3D application

Edit the tile with a third-party modeler like Bentley Descartes, Autodesk 3ds Max, Rhinoceros 3D, Autodesk Maya, Autodesk Mudbox , Autodesk MeshMixer , MeshLab ...

### 5. Import retouched tiles into ContextCapture Master

In ContextCapture Master: at the reconstruction level, in the Reference 3D model tab, click on Import retouched tiles.

Add the directory containing the modified tiles with the Add retouched tiles directory button in the table Geometry touchup or Texture and geometry touchup, depending on the type of modification that was performed.

# ContextCapture Master

## Retouching

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Click the Import retouched tiles button to close the dialog.

See also [Reference model](#) (on page 142).

It is recommended to check the imported tiles in ContextCapture Viewer: at the Reconstruction level, in the Reference 3D model tab, right click on a tile and choose Open tile with ContextCapture Viewer.

See also [Reference model](#) (on page 142).

### 6. Restart production

 Retouching a tile turns the entire productions that include it into the state requiring update.

You can update your production either by:

- Updating the production(s) that include(s) the modified tiles: press the Submit update button at production level to allow the modifications to be taken into account in a production.
- Submit (ting) a new production that will take into account the modified tile(s).

**Note:** In case you want to cancel modifications that were made to tiles outside ContextCapture Master, click the *Reset tiles* button at the reconstruction level in the *Reference 3D model* tab. It will open a dialog where you can select the tiles that you want to reset and compute again. See also [Reference model](#) (on page 142).



*Figure 104: Example of retouching on texture and geometry*

## Workflow diagram

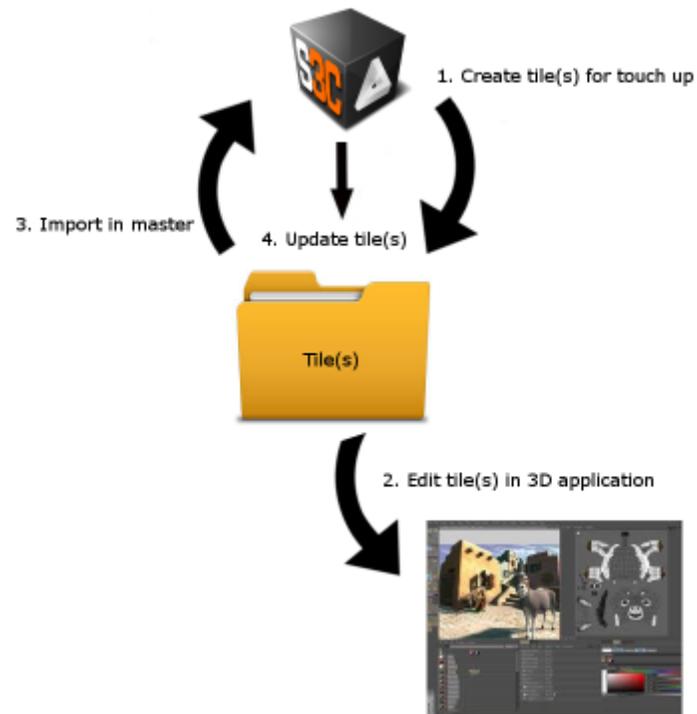
Simple method without version management

The smoothest process, but with no possibility to compare different versions.

# ContextCapture Master

Retouching

---

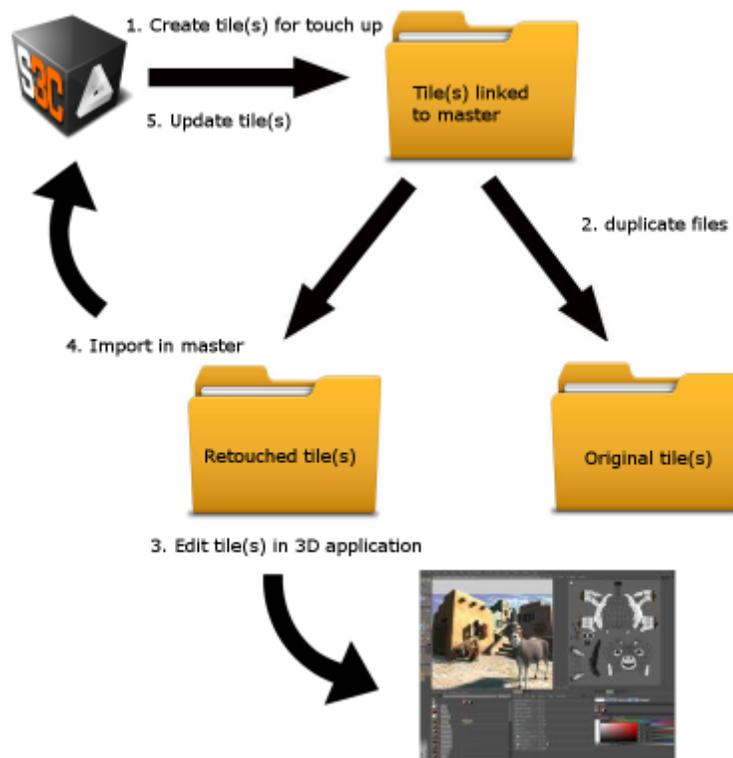


With version management

More elaborate, but allows to keep track of every version.

# ContextCapture Master

Spatial reference system



## Spatial reference system

Georeferenced projects will require to define a cartographic system by selecting a *Spatial Reference System (SRS)* at the reconstruction (Spatial framework) and production levels.

The interface used for Spatial reference system choice proposes a default selection adapted to the context, a list of recent choices, and a direct access to the Spatial reference system database for more choice.

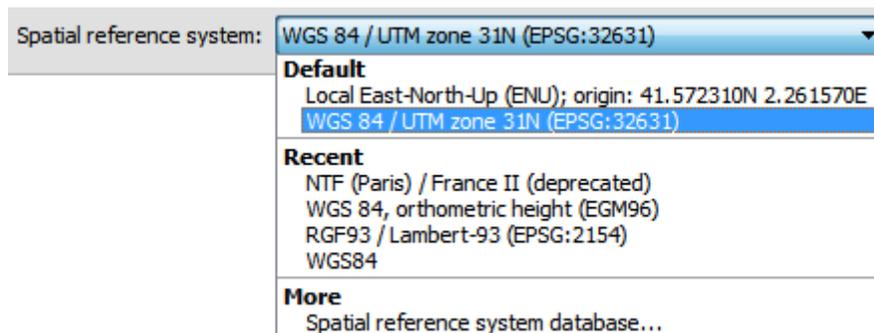


Figure 105: Spatial reference system choice

## Spatial reference system database

In the spatial reference system list, click on *More: Spatial reference system database* to access the database.

## ContextCapture Master

### Spatial reference system

The database proposes more than 4000 spatial reference systems and is extensible with custom user definitions.

Spatial reference systems are sorted by type:

- Cartesian systems: 3D cartesian coordinate systems, including ECEF (geocentric) and Local East-North-Up (ENU) coordinate system.
- Geographic systems: coordinate systems based on a spheroid, for instance the WGS 84 latitude/longitude coordinate system.
- Projected systems: map projections sorted by projection type (UTM, Lambert Conformal Conic, etc.). Projected systems also include the specific Web map projection Bing Maps system.
- User defined systems: custom user definition.

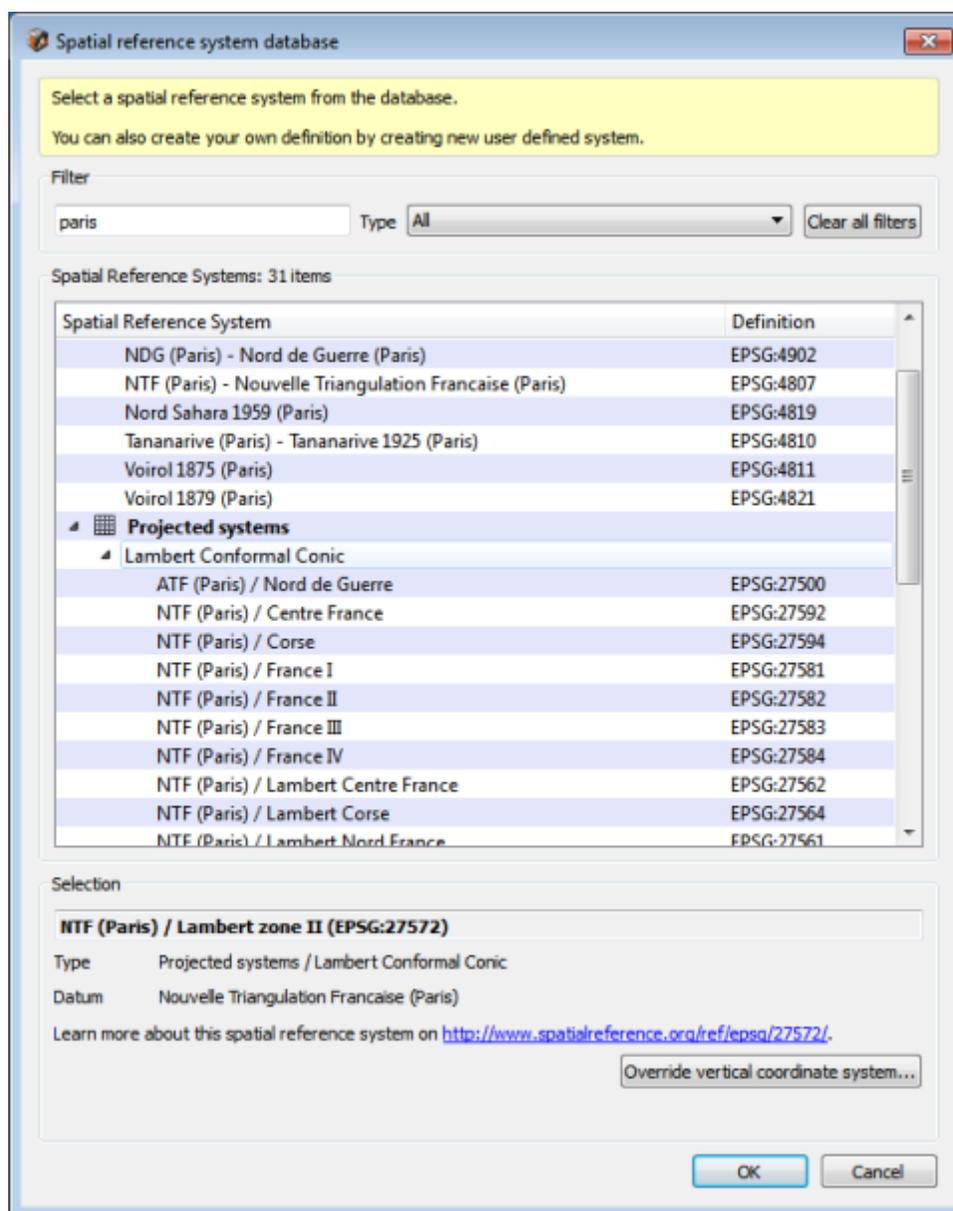


Figure 106: Selection of a Spatial reference system from the database

## ContextCapture Master

### Spatial reference system

---

Use the filter to quickly find an existing Spatial reference system in the database and select an item in the filtered table.

For specific types of systems you may be asked to enter additional parameters:

- Local East-North-Up (ENU): needs latitude and longitude of the origin. See also [Useful concepts](#) (on page 15).
- Bing Maps system: needs level of detail from 1 to 23. See also <http://msdn.microsoft.com>.
- User defined system: needs name and definition (see after).

### Exporting Spatial reference system

Projected, geographic or user defined spatial reference systems can be exported in standard PRJ files including the WKT definition.

Right-click on an item and choose *Export* to create a PRJ file.

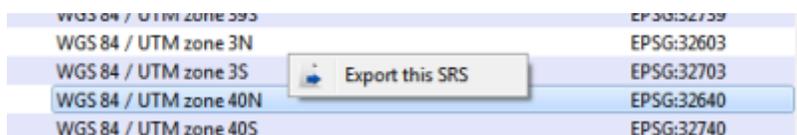


Figure 107: Export of SRS definition

Exporting SRS allows to adjust a SRS definition externally or export a user defined SRS to another computer.

### Vertical coordinate system

Geographic and projected systems use the datum on which they are based as height reference (ellipsoidal height).

For convenience you can override the vertical coordinate system to use another reference for heights.

 Some vertical coordinate system definitions are based on geoid approximation subject to sampling and interpolation, resulting in loss of vertical accuracy.

Click on *Override vertical coordinate system* to select a new reference for heights.

# ContextCapture Master

Spatial reference system

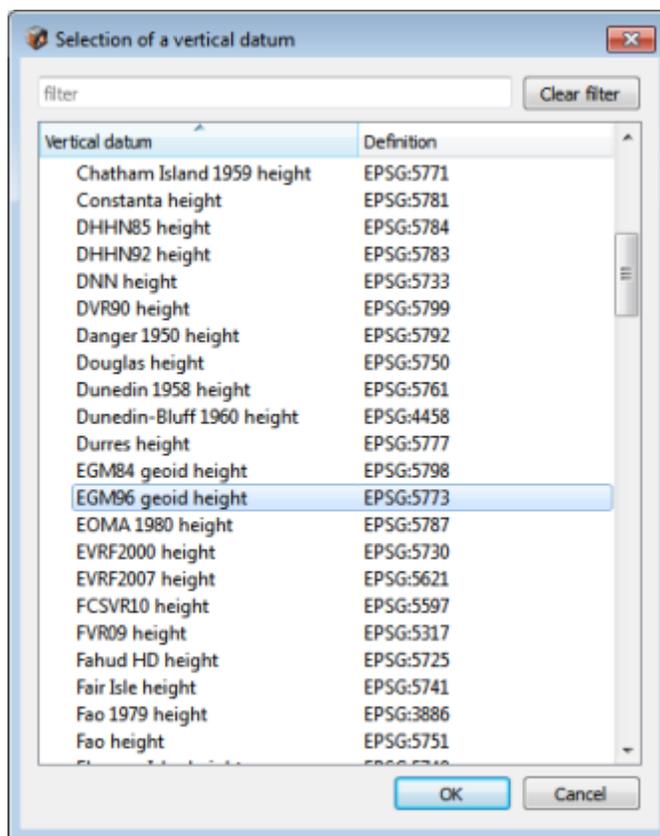


Figure 108: Overriding vertical coordinate system

Upon confirmation of your choice, a new user defined system is created with the overridden vertical coordinate system.

**Note:** Ellipsoid height may be confusing compared to traditional mapping data using orthometric height or mean sea level (MSL) as reference.

Using EGM96 geoid as vertical coordinate system allows to get a good approximation of mean sea level (MSL) heights.

## User defined system

[Create custom spatial reference systems](#) (on page 196)

To find a spatial reference system, you can visit <http://www.spatialreference.org/>.

### PROJ.4

PROJ.4 declaration allows to enter a custom projection system (for instance "+proj=utm +zone=11 +datum=WGS84").

See also <http://trac.osgeo.org/proj/wiki/GenParms>.

### Well Known Text (WKT)

## ContextCapture Master

### Spatial reference system

OpenGIS Well Known Text format for coordinate systems can be provided in an attached PRJ file. In such case, enter the projection file path as SRS definition (for instance "C:\projections\myProjection.prj").

Example of WKT definition contained in a PRJ (.prj) file:

```
GEOGCS["WGS_84",
  DATUM["WGS_1984",
    SPHEROID["WGS_84",6378137,298.257223563,
      AUTHORITY["EPSG",7030]],
    TOWGS84[0,0,0,0,0,0,0],
    AUTHORITY["EPSG",6326]],
  PRIMEM["Greenwich",0,AUTHORITY["EPSG",8901]],
  UNIT["DMSH",0.0174532925199433,AUTHORITY["EPSG",9108]],
  AXIS["Lat",NORTH],
  AXIS["Long",EAST],
  AUTHORITY["EPSG",4326]]
```

#### Additional data

Some spatial reference systems use external dependencies which, prior to their use, must be installed in the "data\gdal" subdirectory of ContextCapture installation directory.

For instance, a spatial reference system with a custom vertical coordinate system may use a GTX grid to approximate the geoid.

### Create custom spatial reference systems

You can create custom spatial reference systems in three steps:

1. Select the item *Define new user system* to start the creation of a new spatial reference system.

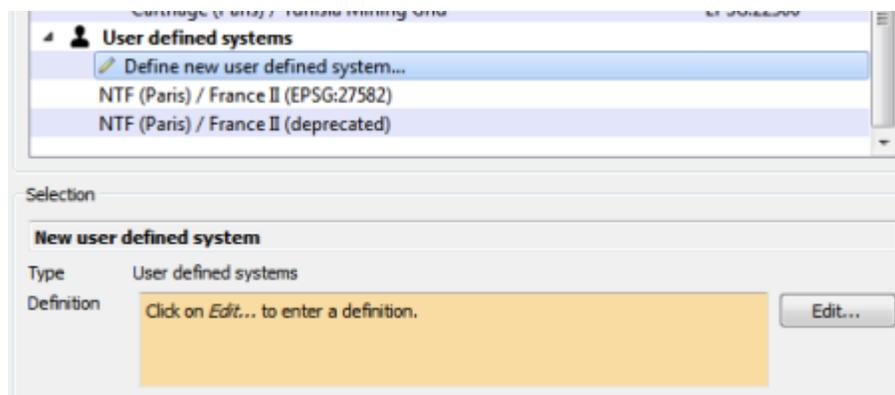


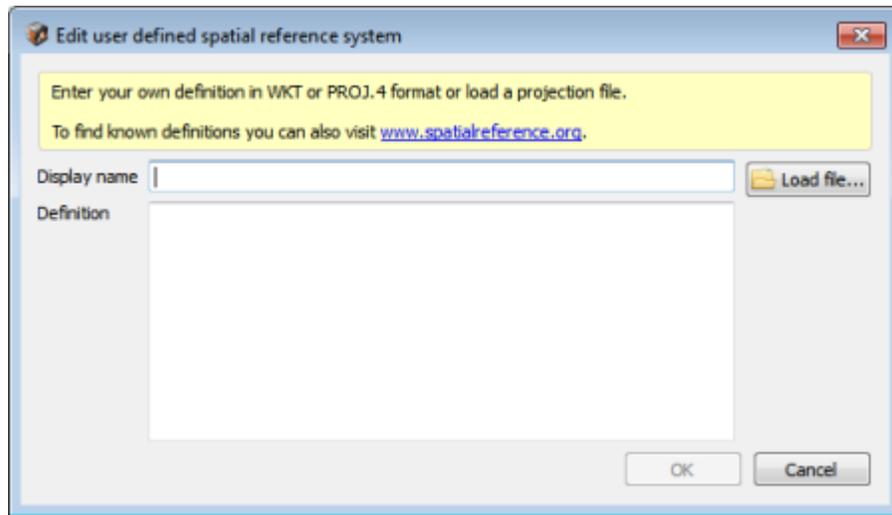
Figure 109: Starting the creation of a new user defined system

2. Click on *Edit* to define the new spatial reference system.

# ContextCapture Master

Spatial reference system

---



3. Enter a display name and the definition of the new user defined system.

Any well known SRS definition can be entered, which includes PROJ.4 declarations, Well Known Text (WKT), or the name of a PRJ file containing a definition.

To find a spatial reference system, you can visit [www.spatialreference.org](http://www.spatialreference.org).

# 5

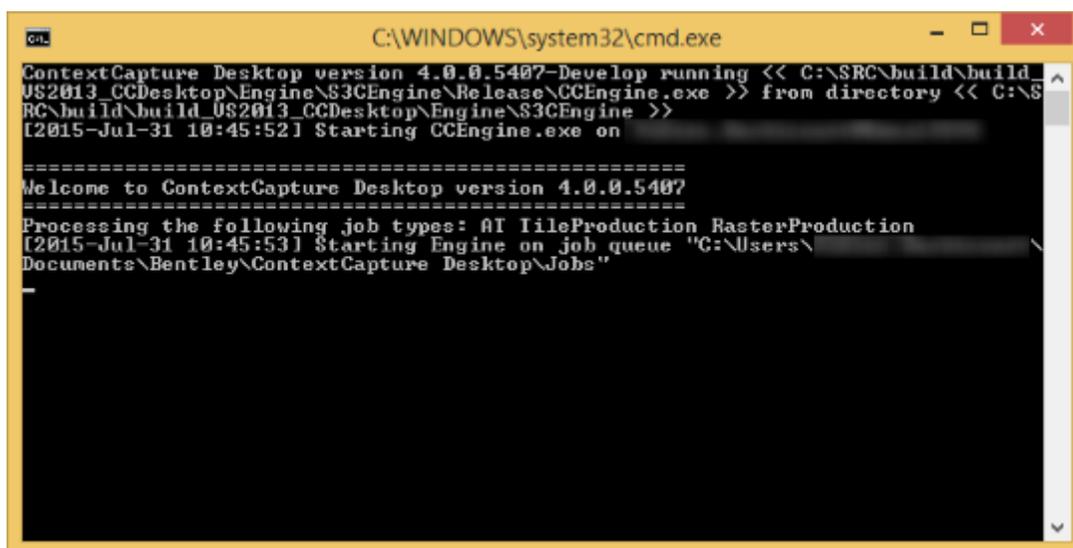
## ContextCapture Engine

ContextCapture Engine is the worker module of ContextCapture . It runs on a computer in the background, without user interaction. When it is not busy, the Engine takes a pending job in the queue, depending on its priority and date of submission, and executes it. A job usually consists of an aerotriangulation or 3D reconstruction process, using various computationally intensive algorithms (keypoint extraction, automatic tie point matching, bundle adjustment, dense image matching, robust 3D reconstruction, seamless texture mapping, texture atlas packing, level-of-detail generation, ...).

ContextCapture Engine makes an extensive use of general-purpose computation on graphics processing units (GPGPU). Each Engine can exploit a single GPU.

### Starting/ending the engine

Click on the ContextCapture Engine desktop shortcut to start the engine.



```
C:\WINDOWS\system32\cmd.exe
ContextCapture Desktop version 4.0.0.5407-Develop running << C:\SRC\build\build_US2013_CCDesktop\Engine\S3CEngine\Release\CCEngine.exe >> from directory << C:\SRC\build\build_US2013_CCDesktop\Engine\S3CEngine >>
[2015-Jul-31 10:45:52] Starting CCEngine.exe on
=====
Welcome to ContextCapture Desktop version 4.0.0.5407
=====
Processing the following job types: AI TileProduction RasterProduction
[2015-Jul-31 10:45:53] Starting Engine on job queue "C:\Users\Documents\Bentley\ContextCapture Desktop\Jobs"
```

Figure 110: ContextCapture Engine window

Once running, ContextCapture Engine listens to the Job queue directory which is configured thanks to ContextCapture Settings (Refer to [Installation](#) (on page 10)).

To close ContextCapture Engine, simply close the engine console. Any running Job will be moved back into the job queue, with a pending status and its original priority. Pending jobs will remain in the Job queue , waiting to be processed by a next execution of ContextCapture Engine.

## ContextCapture Engine

ContextCapture Engine specialization

---

### ContextCapture Engine specialization

By default, ContextCapture Engine processes both *aerotriangulation* and *reconstruction* jobs.

On a computer cluster, it may be useful to specialize engines to process only a specific type of job.

To specialize ContextCapture Engine, run it with the following commands:

- Aerotriangulation jobs only:

```
CCEngine --type AT
```

- TileProduction and RasterProduction jobs only:

```
CCEngine --type "TileProduction  
RasterProduction"
```

### Limiting the number of threads

Set the environment variable `CC_MAX_THREADS` to define the maximum number of parallel threads executing ContextCapture Engine.

This advanced setting may be useful to preserve responsiveness of other applications running on the same computer (e.g. leave one core for ContextCapture Master if it is installed on the same computer).

### Restrictions

Remote Desktop Connection

 ContextCapture Engine cannot work through a Microsoft Remote Desktop Connection because hardware acceleration is disabled. However you can use VNC or a remote administration software like TeamViewer.

Windows session

 Switching Windows user while ContextCapture Engine is running will cause running computations to fail because hardware acceleration is disabled when the user is not connected.

# 6

## ContextCapture Viewer

ContextCapture Viewer is ContextCapture 's free lightweight visualization module. It is optimized for ContextCapture 's 3MX format, which handle level-of-detail, paging and streaming, thus allowing visualization of terabytes of 3D data, locally or online, with a smooth frame rate. You can use ContextCapture Viewer in conjunction with ContextCapture Master to control production quality all along the workflow. You can also use it to navigate final results.

*ContextCapture Viewer* is integrated with ContextCapture , but it can also be installed separately as a stand-alone desktop application. You can freely download the installer of its latest version from <http://www.bentley.com/>.

ContextCapture Viewer is available for Windows 64-bit.

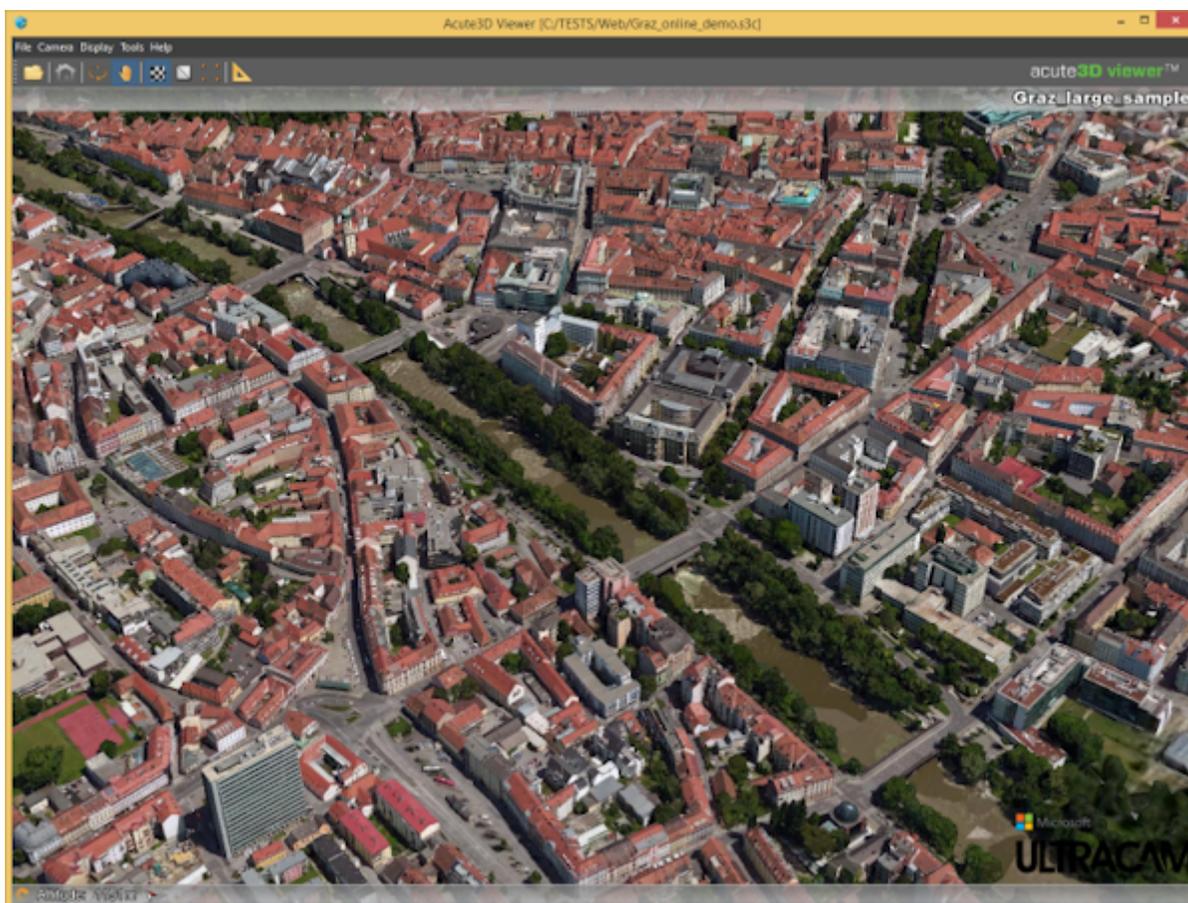


Figure 111: ContextCapture Viewer

## ContextCapture Viewer

### Scene composition

---

ContextCapture Viewer can read the following 3D formats: 3MX, 3SM, S3C, A3D ( ContextCapture Master internal format), OBJ, FBX, PLY, OSGB.

Please consult the ContextCapture Viewer User Manual for more information.

## Scene composition

ContextCapture S3C Composer allows editing an existing S3C model to re-compose the 3D scene or add credits.

[ContextCapture S3C Composer](#) (on page 205).

# 7

## ContextCapture Web Viewer

---

The ContextCapture Web Viewer is the visualization software that allows users to view and navigate ContextCapture 3MX models directly in a web browser.

ContextCapture Web Viewer is a cross-platform WebGL 3D viewer, suitable for desktops, tablets and smartphones. The Web Viewer can be embedded easily in any web page. It works within any browser supporting WebGL, without the use of plug-ins.

3D models are loaded and displayed using level-of-detail (LOD), paging and streaming, and users can measure distances and pick GPS coordinates.

## ContextCapture Web Viewer

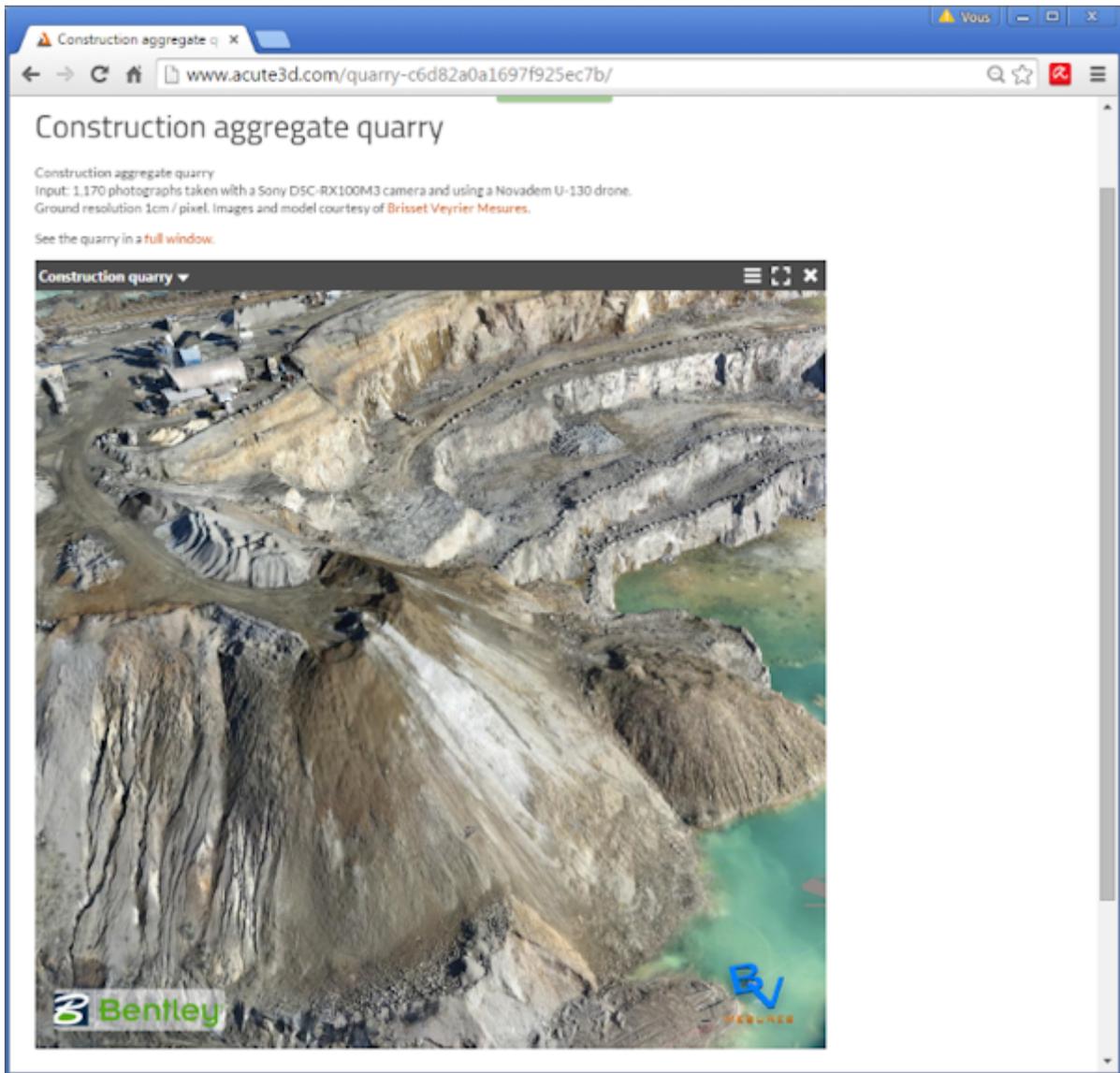


Figure 112: Example of a 3MX production embedded in a web page with ContextCapture Web Viewer.

For more details, see Chapter 15, [3MX Web Deployment](#) (on page 229).

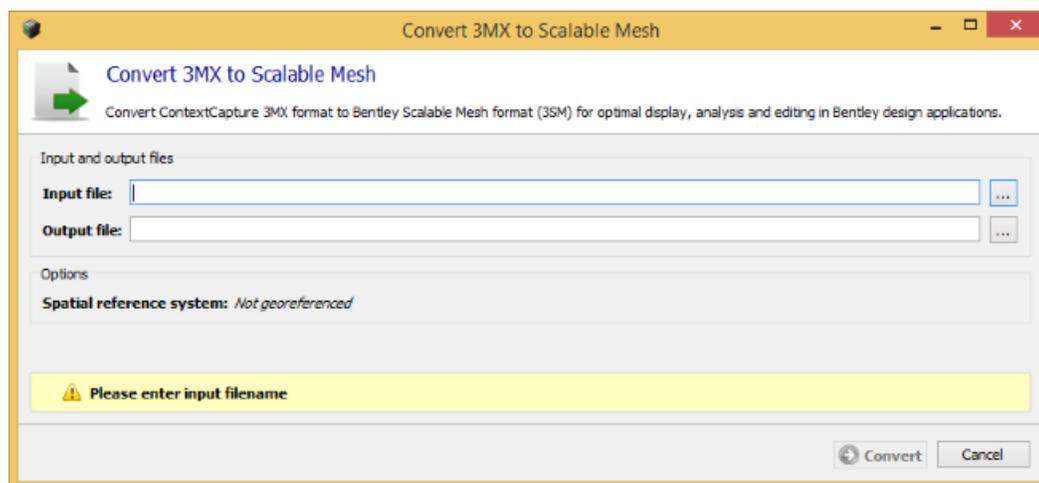
# 8

## Convert 3MX to Scalable Mesh

### Menu Tools | Convert 3MX to Scalable Mesh

Use this tool to convert existing 3MX models to Scalable Mesh format (3SM).

Limitation: The conversion does not support 3MX models including nodes with several texture maps. It may happen on 3MX models produced without LOD, on 3MX models produced with small maximum texture size, or on standard 3MX models in very rare cases.



For convenience, this tool is also available on any completed 3MX production.

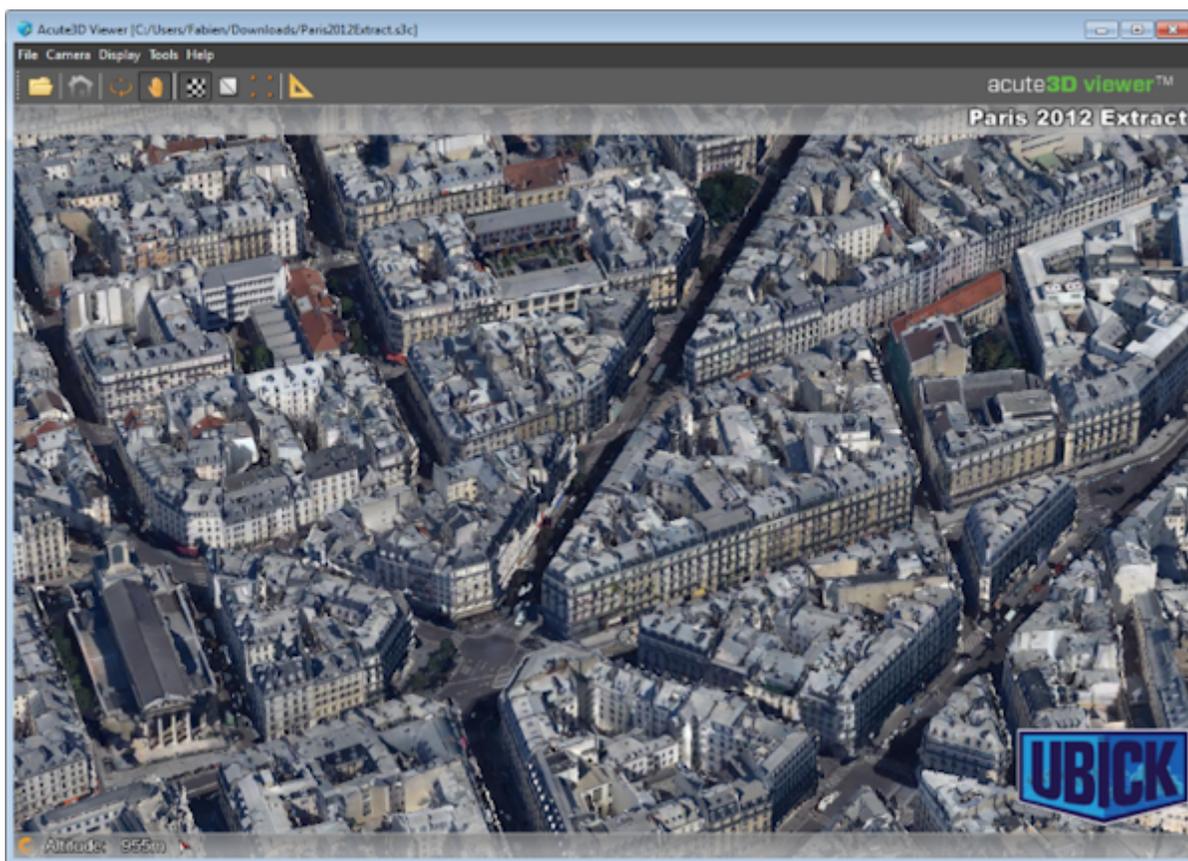
# 9

## ContextCapture S3C Composer

ContextCapture S3C Composer is dedicated to the preparation of projects in S3C format for visualization in ContextCapture Viewer.

Warning: This tool is deprecated, to open it, launch bin/CC\_S3CComposer.exe from ContextCapture's installation directory.

ContextCapture S3C Composer allows editing of an existing S3C scene file produced by ContextCapture in order to re-compose the 3D scene or add credits.



ContextCapture S3C Composer interface allows to:

- Edit the list of models included in the scene,
- Add title and logo,
- Modify the reference coordinate system,

## ContextCapture S3C Composer

### ContextCapture S3C Composer Main Interface

- Choose navigation and motion constraints,
- Setup a S3C scene for web publishing,
- Edit advanced options.

## ContextCapture S3C Composer Main Interface

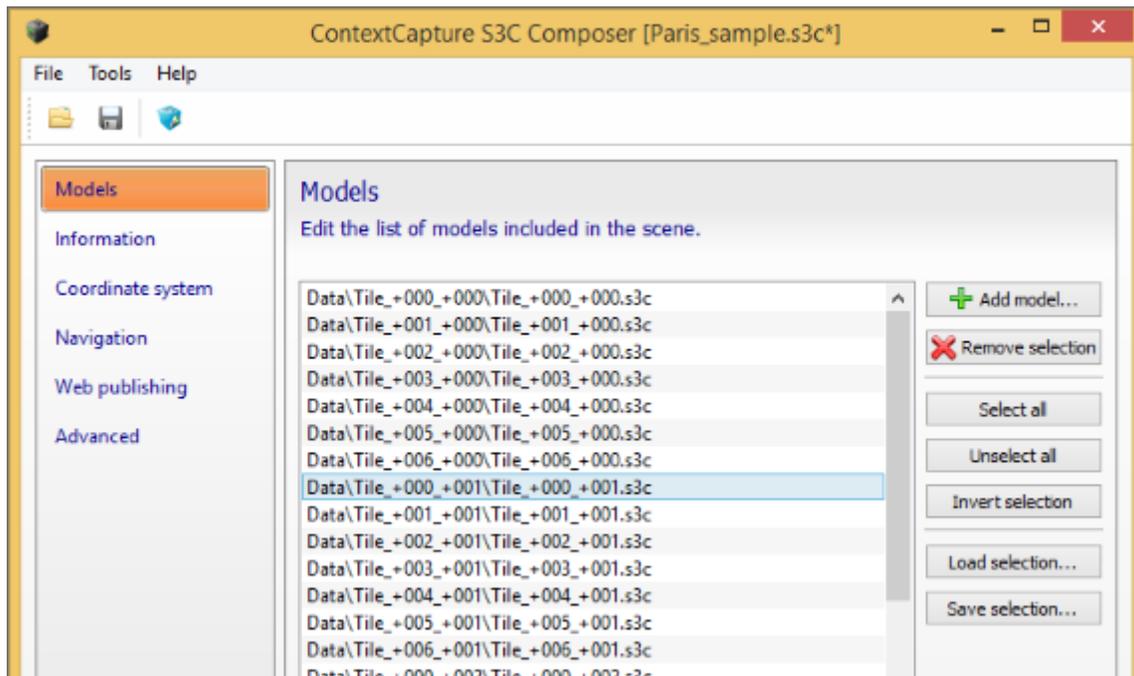


Figure 113: ContextCapture S3C Composer main interface

## Models

*Edit the list of models included in the scene.*

An S3C scene is composed of tiles. You can add or remove tiles to/from the model.

It is possible to add tiles coming from a different production if its coordinate system is compatible.

External OBJ or FBX models can also be included in the scene.

 Large OBJ or FBX files may slow down 3D navigation, because they do not feature level-of-detail.

Use the preview function available in the context menu (right-click) to get a quick preview of a selection of models in ContextCapture Viewer.

## Information

*Set the scene title and credits information.*

### Title

A title can be added and will appear at the top right corner of the ContextCapture Viewer interface.

# ContextCapture S3C Composer

ContextCapture S3C Composer Main Interface

---

## Logo

A logo can be added, it will appear at the bottom right corner of the ContextCapture Viewer interface.

PNG or JPG files are imported into a .a3d file (proprietary format) and copied next to the S3C scene file.

Logo dimensions are limited to 300x300 pixels. Larger images are automatically reduced.

## Coordinate system

*Check georeferencing and coordinate system.*

*Model position*

Displays the scene coordinate system.

## Navigation

*Choose navigation mode and motion constraints.*

### **Minimum/Maximum height constraint**

Enable a constraint on the height of the camera.

Choose the height mode Relative to ground to set the height constraint relative to the ground.

### **Maximum oblique viewing angle constraint**

Enable a constraint on the angle between the vertical direction and the camera direction.

### **Navigation mode**

*Select the default navigation mode.*

The navigation mode of the scene can later be changed in ContextCapture Viewer.

## Web publishing

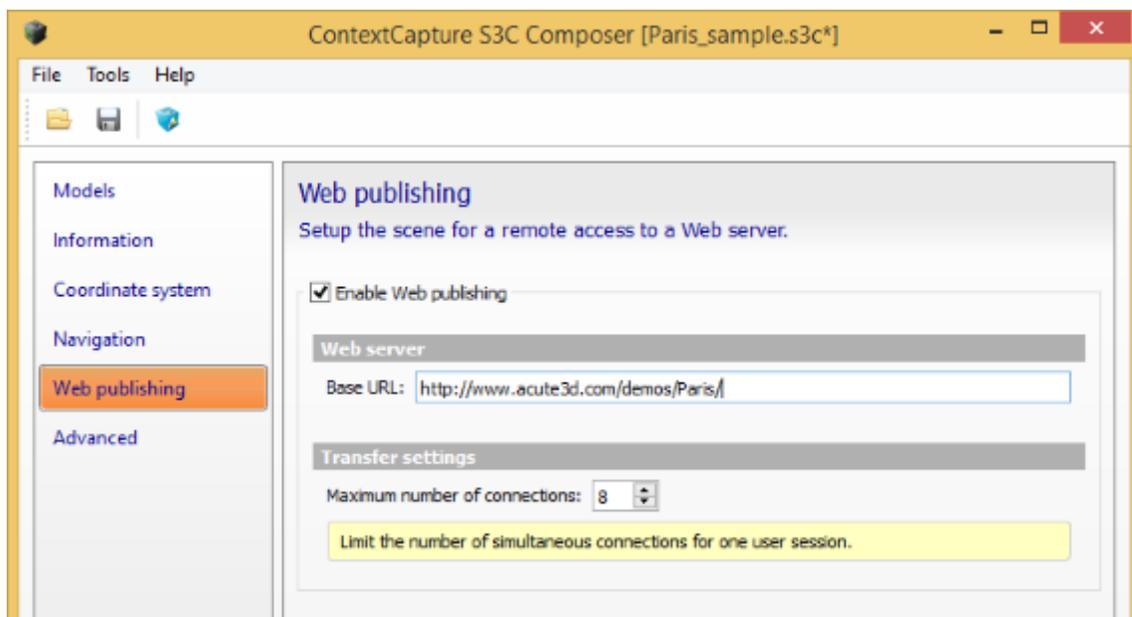
*Setup a S3C scene for a remote access to a Web server.*

### **Web server**

*Base URL: Select the base URL on the Web server.*

## ContextCapture S3C Composer

Export instant loading scene file



ContextCapture Viewer resolves relative paths of the different tiles specified in the S3C scene to a full URL, using this setting.

### Transfer settings

*Maximum number of connections.*

ContextCapture Viewer downloads the different nodes of the 3D scene using several simultaneous connections, in order to reduce latency. The number of simultaneous connections cannot exceed this setting.

See also [Web publishing](#) (on page 29).

## Advanced

Define advanced scene options.

## Edit command line

*Menu Tools > Edit command line*

To allow scripting, the scene can also be composed through a command line.

## Preview with ContextCapture Viewer

*Menu Tools > Preview with ContextCapture Viewer*

Preview the defined scene with ContextCapture Viewer.

## Export instant loading scene file

*Menu File > Export instant loading scene file*

## ContextCapture S3C Composer

Export instant loading scene file

---

**Export instant loading scene file is available only in ContextCapture Center Edition. See [Software Editions](#) (on page 27).**

For very large datasets (with several hundred tiles), the default scene structure is not suited for efficient 3D visualization: loading and display performances may be affected, especially on the web.

Exporting instant loading scene file allows to generate an instant loading scene format including additional data and specific motion constraints which are suited for very large dataset visualization.

The exported scene file integrates a symbolic representation of tiles which is used before their actual loading, a specific LOD structure, and motion constraints on viewing angle and height.



*Figure 114: 3D visualization of an instant loading scene file (at the beginning of loading).*

This tool is suited only for scenes composed of a 2D tiling with a large number of tiles (typically >50).

# ContextCapture S3C Composer

Export instant loading scene file

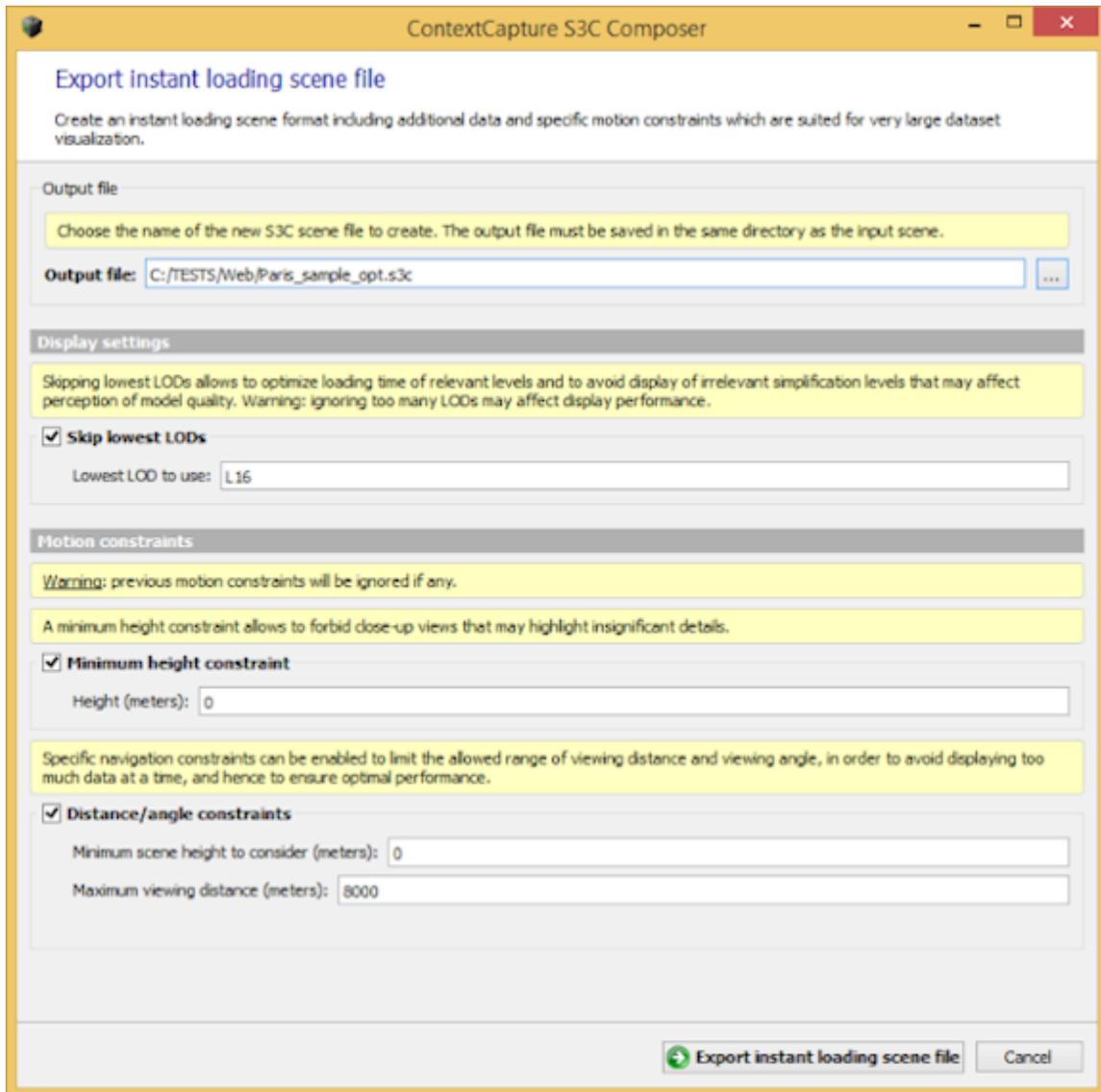


Figure 115: Exporting instant loading scene file

## Output file

Enter the name of the new S3C scene file to create.

The output file must be saved in the same directory as the input scene.

**Note:** The output file is created with an associated A3D file which is also needed for the 3D visualization.

## Options

### Skip lowest LOD

Define the lowest level-of-detail to use for the representation.

Skipping lowest LODs allows to optimize loading time of relevant levels (and to avoid display of irrelevant simplification levels that may affect perception of model quality).

## ContextCapture S3C Composer

Export instant loading scene file

---

Warning: ignoring too many LODs may affect display performance.

The starting LOD must be set according to the available level-of-details in scene tiles (eg. *L16* corresponds to the file "Tile\_+000\_+000\_ **L16** \_00.a3d"). See also [Output formats](#) (on page 161)

Disable this option to use the lowest level-of-detail available.

### **Minimum height constraint**

Motion constraint on the minimal height of the camera.

A minimum height allows to forbid close-up views that may highlight insignificant details.

### **Distance/angle constraints**

Specific navigation constraints can be enabled to limit the allowed range of viewing distance and viewing angle, in order to avoid displaying too much data at a time, and hence to ensure optimal performance.

Enter the minimum scene height to consider in the input model, and the maximum viewing distance to adjust the motion constraint, it also impacts the distance threshold for displaying a symbolic representation of tiles.

 **Known limitations: display policy and motion constraints of instant loading scene files are not suited for areas including large variations in relief.**

# 10

## ContextCapture Target Creator

---

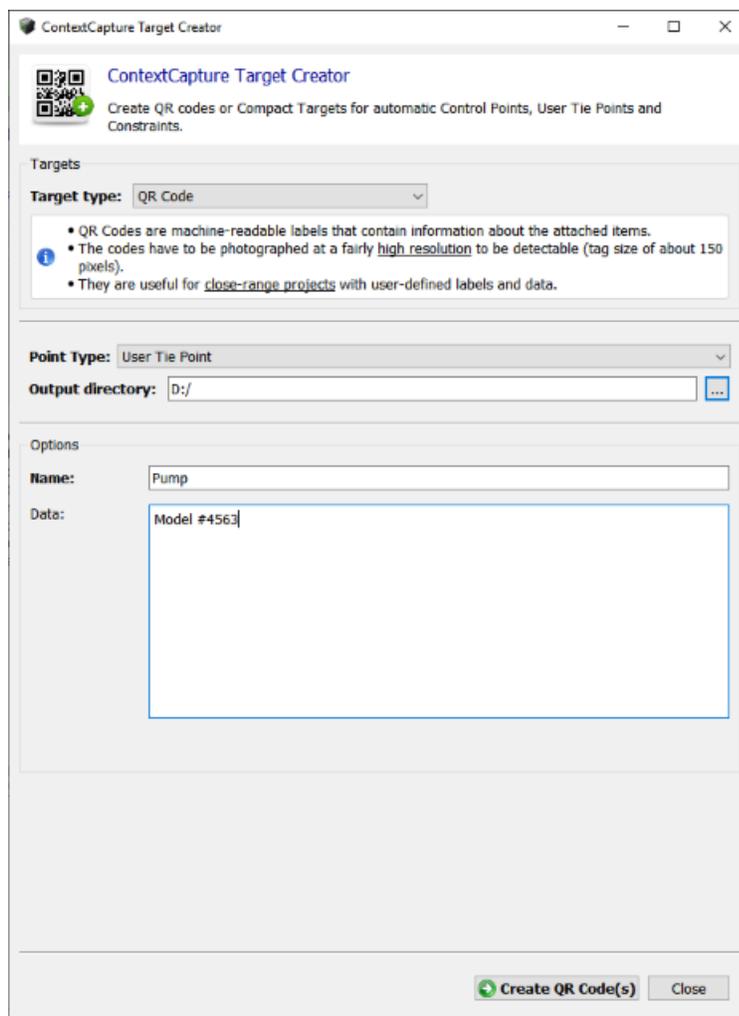
ContextCapture Target Creator is a tool for creating printable targets based on QR codes or compact targets Chili tags and April tags. Targets can be automatically extracted from photos by ContextCapture to automate survey data creation.

Three types of surveys data can be created from target:

- User Tie Point: : For QR Codes, user should specify a name and an optional description.
- Control Points (QR Code only): it will be used for automatic rigid registration of the scene if at least 3 of these targets are detected. User should specify a name for the control point. Predefined 3D coordinates with a spatial reference system can be attached for automatic geo-registration. Coordinates can also remain blank and be defined afterwards by the user in the input block using a control point with the exact same name.
- Constraint (QR code only): it will be used as automatic constraint. There are four types of constraints:
  - Origin: set the Origin (0,0,0) at the middle of the QR point.
  - Scale: set a distance between 2 QR points.
  - Axis: set X, Y or Z axis along the two QR codes.
  - Plane: set X, Y or Z axis along the two first QR codes, and orient the assigned axis along the third QR code.

Note that Axis and Plane constraints cannot be used in the same scene, and two similar constraints cannot be used in the same scene either. For more information, consult the Surveys: Positioning Constraints section.

# ContextCapture Target Creator



ContextCapture MasterKernel SDK is a software development kit including a Python module, that allows programmatic access to all the features of ContextCapture Master. This module acts in the place of the user interface for full project creation, edition and monitoring.

ContextCapture MasterKernel SDK is available only in ContextCapture Center Edition. For more information on the editions please check [Software Editions](#) (on page 27).

The ContextCapture MasterKernel Python module, CCMasterKernelPy, allows the development of customized ContextCapture applications in a simple manner thanks to Python scripts, like customized and/or automated 3D reconstruction processes.

The module API (Application Programming Interface) allows the control of all items used in a ContextCapture Master project (CCM file):

- Project: creation, saving, edition, option settings, project tree management.
- Block: import (Excel/XML), export (KML, XML, unwrapped photos), split, extract, photos/photogroup creation and edition including camera properties and 3D position/rotation, control points creation and edition (3D positions and image measurements), user tie points creation and edition.
- AT (Aerotriangulation): components, positioning modes, settings, job submission and monitoring/control, export of the aerotriangulation report.
- Reconstruction: spatial framework (SRS, region of interest, tiling), reconstruction constraints, reference 3D model (import/export retouches, color equalization), processing settings, export tiling to KML.
- Production: control of all parameters (purpose, format, options, extent and destination), jobs submission and monitoring/control.
- Job queue monitoring.
- Application settings: license checking, version control, software update checking on the internet.

The API also includes various tools for data exchange (property tree, geometry), and geodesic computations.

For more details about the SDK and the Python module API, please refer to ContextCapture SDK documentation in the ContextCapture installation directory.

# 12

## Job Monitoring

### Project monitoring from ContextCapture Master

ContextCapture Master includes monitoring features to manage jobs related to the active project.

There are several types of jobs:

- An Aerotriangulation job is created when submitting block aerotriangulation. Aerotriangulation job monitoring is done from the [General](#) (on page 47).
- TileProduction or RasterProduction jobs occur when submitting production. Production job monitoring is done from the [General](#) (on page 176).

The ContextCapture Master interface allows to submit, cancel, or resubmit jobs, only for jobs related to the active project.

ContextCapture Master also includes a [Job Queue Monitor](#) (on page 179) that allows to check job queue status.

### Managing the job queue

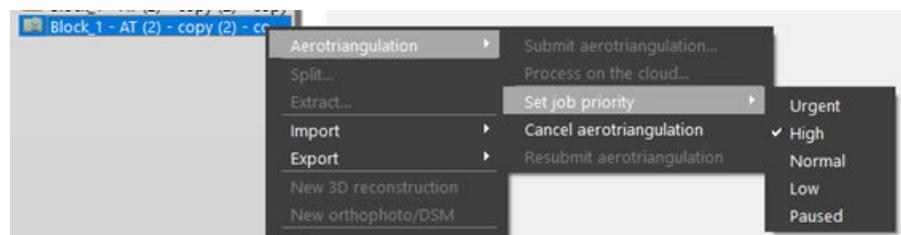
*Managing the job queue allows to control all submitted jobs, from all projects and operators.*

Managing the job queue, is only possible programmatically through ContextCapture MasterKernel SDK.

See ContextCapture MasterKernel SDK documentation to learn more.

Job priorities can be changed in contextual menu of AT Jobs or Production jobs and drive the priorities between jobs in a same job queue.

AT jobs are set to "High" by default.

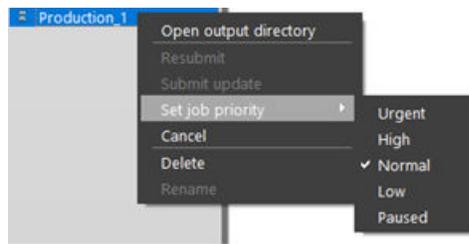


Reconstruction production are set to "Normal" by default.

## Job Monitoring

Managing the job queue

---



Select "Urgent" or "High" if you need specific jobs to take advantage over others in the queue.

Select "Pause" to pause the selected job, (note that the current task of the job will be finished first).

# 13

## ContextCapture camera model

---

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### Equations of the camera models

#### Perspective camera model

The world-to-image projection is given by:

$$x = F . D( \Pi( O . R(X - C) ) ) + x_0$$

where:

$X$  is a 3D column vector representing the position of the scene point in the world spatial reference system,

$x$  is a 2D column vector representing the position of the image point, in pixels. The origin is the center of the upper-left image pixel, the x-axis is oriented to the right side of the image, and the y-axis is oriented to the bottom of the image.

$C$  is a 3D column vector representing the position of the camera center.

$R$  is a  $3 \times 3$  rotation matrix representing the rotation of the camera, which maps the axes of the world spatial reference system to the camera axes defined by camera orientation.  $R$  can specified either from:

$$R = \begin{bmatrix} m_{00} & m_{01} & m_{02} \\ m_{10} & m_{11} & m_{12} \\ m_{20} & m_{21} & m_{22} \end{bmatrix}$$

Its coefficients:

## ContextCapture camera model

Equations of the camera models

Omega/Phi/Kappa angles:

$$R = \begin{bmatrix} \cos \varphi \cos \kappa & \cos \omega \sin \kappa + \sin \omega \sin \varphi \cos \kappa & \sin \omega \sin \kappa - \cos \omega \sin \varphi \cos \kappa \\ -\cos \varphi \sin \kappa & \cos \omega \cos \kappa - \sin \omega \sin \varphi \sin \kappa & \sin \omega \cos \kappa + \cos \omega \sin \varphi \sin \kappa \\ \sin \varphi & -\sin \omega \cos \varphi & \cos \omega \cos \varphi \end{bmatrix}$$

Heading/Roll/Pitch angles:

$$R = \begin{bmatrix} \cos H \cos R + \sin H \sin P \sin R & -\sin H \cos R + \cos H \sin P \sin R & -\cos P \sin R \\ \sin H \cos P & \cos H \cos P & \sin P \\ \cos H \sin R - \sin H \sin P \cos R & -\sin H \sin R - \cos H \sin P \cos R & \cos P \cos R \end{bmatrix}$$

Yaw/Pitch/Roll angles:

$$R = \begin{bmatrix} \cos R \cos Y - \sin R \sin P \sin Y & -\cos R \sin Y - \cos Y \sin R \sin P & \cos P \sin R \\ \cos Y \sin R + \cos R \sin P \sin Y & \cos R \cos Y \sin P - \sin R \sin Y & -\cos R \cos P \\ \cos P \sin Y & \cos P \cos Y & \sin P \end{bmatrix}$$

with:

$(Y, P, R) = (0, 0, 0)$  meaning that the camera is looking horizontally in the Y direction (X axis on the right, Z axis up).

Yaw angle being the clockwise rotation around Z axis.

Pitch angle being the counter clockwise rotation around X axis.

Roll angle being the clockwise rotation around Y axis.

$O$  is a  $3 \times 3$  rotation matrix bringing the camera axes defined by camera orientation to the canonical camera axes (x-axis oriented to the right side of the image, y-axis oriented to the bottom of the image, and z-axis oriented to the front of the camera):

"XRightYDown":	$O = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$
"XLeftYDown":	$O = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$
"XLeftYUp":	$O = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$
"XRightYUp":	$O = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$

## ContextCapture camera model

Equations of the camera models

"XDownYRight":	$O = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & -1 \end{bmatrix}$
"XDownYLeft":	$O = \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$
"XUpYLeft":	$O = \begin{bmatrix} 0 & -1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & -1 \end{bmatrix}$
"XUpYRight":	$O = \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

$\Pi: R^3 \rightarrow R^2$  is the perspective projection function defined by:

$$\Pi(u, v, w) = (u/w, v/w)$$

$D: R^2 \rightarrow R^2$  is the distortion function defined by:

$$D(u, v) = \left( \begin{array}{l} (1 + K_1 r^2 + K_2 r^4 + K_3 r^6)u + 2P_2 uv + P_1 (r^2 + 2u^2) \\ (1 + K_1 r^2 + K_2 r^4 + K_3 r^6)v + 2P_1 uv + P_2 (r^2 + 2v^2) \end{array} \right), \text{ where } r^2 = u^2 + v^2$$

(Please note that, in some other conventions, the roles of  $P_1$  and  $P_2$  are reversed).

$F = \begin{bmatrix} f & s \\ 0 & \rho f \end{bmatrix}$  is the focal matrix, where  $f$  is the focal length of the camera in pixels,  $s$  the skew parameter and  $\rho$  the pixel ratio.

$x_0$  is a 2D column vector representing the position of the principal point of the camera, in pixels. The origin is the center of the upper-left image pixel, the x-axis is oriented to the right side of the image, and the y-axis is oriented to the bottom of the image.

## Fisheye camera model

The world-to-image projection is given by:

$$x = F \cdot \Pi(O \cdot R(X - C)) + x_0$$

where:

## ContextCapture camera model

Equations of the camera models

---

$X, C, R, O$  and  $x_0$  are defined as in the perspective camera model.

$\Pi: R^3 \rightarrow R^2$  is the fisheye projection and distortion function defined by:

- $\theta = \frac{2}{\pi} \arctan\left(\frac{\sqrt{u^2+v^2}}{w}\right)$
- $\rho = p_0 + p_1\theta + p_2\theta^2 + p_3\theta^3 + p_4\theta^4$ , ( $p_i$ ) being distortion coefficients
- $\Pi(u, v, w) = \left(\rho \frac{u}{\sqrt{u^2+v^2}}, \rho \frac{v}{\sqrt{u^2+v^2}}\right)$

$F = \begin{bmatrix} F_{00} & F_{01} \\ F_{10} & F_{11} \end{bmatrix}$  is the fisheye focal matrix, set to  $F_{00} = F_{11} = \frac{\pi f}{2}$ ,  $F_{01} = F_{10} = 0$  when the symmetric mode is chosen,  $f$  being the focal length of the camera, in pixels.

# 14

## ExportUniqueMesh: post-processing tool for generating city-scale 3D models with complete level-of-detail structure

---

### Introduction

### Summary

This document describes the motivation, the usage and the output format of ExportUniqueMesh, a post-processing tool developed by Bentley Systems to generate city-scale 3D models with complete level-of-detail structure from a 3D reconstruction produced with ContextCapture standalone solution.

**Note:** From ContextCapture update 5, ExportUniqueMesh access is made easier through the LOD type 'Quadtree across tiles' on mesh productions. See Production 3D mesh options.

### About this document

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### Motivation

The 3D models produced by ContextCapture are divided into tiles. In its current version, ContextCapture can generate a level-of-detail structure for each tile taken independently, but is not able by default to generate a global level-of-detail structure (e.g., a quadtree) for an entire city.

Such a global level of detail structure is desirable for real-time 3D rendering of an entire city without constraints on viewing altitude or tilt angle. This requires the manipulation of very low resolution versions of large parts of the city, the extreme case being one small 3D mesh to represent the entire city at very low resolution.

# ExportUniqueMesh: post-processing tool for generating city-scale 3D models with complete level-of-detail structure

## Usage

---

Bentley Systems has developed a post-processing tool called ExportUniqueMesh to fulfill this requirement. The same functionality is available through ContextCapture by submitting a production with "LOD Across Tiles" as the LOD scope setting.

## Usage

### Example Usage

```
ExportUniqueMesh "D:/ ContextCapture /Stockholm_140604.txt" -o "D:/ ContextCapture /out" --cache "D:/ ContextCapture /Cache" --scene "Stockholm" --format 3SM --lodType Adaptive --tileOverlap 1.5 --tilingSRS "EPSG:3011" --outputSRS "D:/ ContextCapture /SWEREF99 18 00 (EPSG_3011) + RH2000 height (EPSG_5613).prj" --textureSize 2048
```

### Command-line syntax and allowed options

ExportUniqueMesh -i ... -o ... --tilingSRS ... --outputSRS ... [options]

-i	path of the input tile list (mandatory)
-o	path of the output directory. By default, use the working directory
--cache	path of the cache directory. By default, use the "cache" subdirectory of the working directory
--scene	output scene name. Default: "scene"
--help, -h	produce help message
--tilingSRS	definition of the tiling SRS, or path to its definition (mandatory)
--tileSize	tile size, in the unit of the tiling SRS (mandatory)
--heightRange	height of the tiling in the tiling SRS, in "zmin zmax" format (mandatory)
--textureSize	maximum texture size. Default value is 8192. Minimum accepted value for the texture size is 1024.
--textureQuality	texture quality used for texture map compression between 0 and 100. Default: 75
--textureSharpening	level of texture sharpening. Default: 100

# ExportUniqueMesh: post-processing tool for generating city-scale 3D models with complete level-of-detail structure

## Usage

---

--textureColorSource	color source used for texturing: Visible or Thermal. Default: Visible
--fill	fill color for untextured facets, in RGB format (default: "128 128 128")
--tileOverlap	size of the overlap added around each input tile (absolute unit value). Default: 0
--nodeOverlap	size of the overlap added around the LOD nodes, relatively to the LOD scale
--skirtLength	length of the skirts added at the boundary of LOD nodes, relatively to the LOD scale (read more below). Default: 0 (no skirts)
--format	output format. See below the list of possible values. Default is the 3MX format
--lodType	type of LOD tree. Can be one of: Unary, Quadtree, Octree, Adaptive, BingMaps
--nodeSize	relative size of level-of-detail nodes (read more below). Default: 1
--outputSRS	definition of the output SRS, or path to its definition (mandatory)
--outputOrigin	3D position in the output SRS used as the origin of mesh coordinates. By default, an automatic origin is chosen
--generateWebApp	generate web application for formats supporting it (3MX and Cesium 3D Tiles)
--convertToWebReadyScalableMesh	for 3SM format, convert the output to a Web-Ready Scalable Mesh
--omp	Maximum number of CPU cores used for computation. Default: all CPU cores

Skirt: the skirt is an additional border included around each geometry node, to avoid cracks between the different parts of the mesh. The skirt is not tangent to the 3D model: it lies in the boundary of the 3D region of the node, and it is oriented towards the interior of the 3D model. For example, the skirt between two side-by-side mesh nodes is composed of thin vertical strips. The skirt length depends of the resolution of each node.

# ExportUniqueMesh: post-processing tool for generating city-scale 3D models with complete level-of-detail structure

Usage

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## Documentation

### Input tile list

The tile list must be in ASCII (UTF8 can cause problems). The tile list must contain paths to the tiles of the reference 3D model and extents of the corresponding tiles, in xmin ymin zmin xmax ymax zmax format, with coordinates expressed in the tiling SRS..

For example:

```
l:\3381_Stockholm3D\Stockholm3D\Project
files\Block_19\Reconstruction_1\Productions\Production_22\Tile_+1349_+65882\438212 4602471 146
438362.5 4602597.5 208
```

The tile list can contain tiles from several reconstructions, provided the reconstructions have compatible tilings (same tiling SRS, tiles of the different reconstructions correctly partitioning space).

No tile must be listed twice or more in the tile list.

### Compatibility with older versions of ContextCapture

The --v2 parameter allows to process reference 3D models of ContextCapture version < 3.0.

### Description of the source tiling structure

The structure of the level-of-detail tree is controlled by the extent of the input tiles and by the --lodType and --nodeSize parameters.

The --nodeSize parameter controls the size of nodes. For a default value of 1, the leaf nodes cover about 400 pixels of ground resolution, and every level-of-detail node covers about 400 times the resolution of the node.

The depth of the level-of-detail tree is not uniform. It is adaptive to the resolution of the input tiles.

The output SRS and origin must be specified and can be chosen independently of the settings of the ContextCapture project.

The fill color setting is similar to the "Color of untextured regions" setting of a reconstruction in ContextCapture Master.

### Description of the output quadtree structure

The structure of the quadtree is controlled by the extent of the input tiles, by the --nodeSize parameter and by the --resolution parameter.

The --nodeSize parameter controls the size of nodes. For a default value of 1, the leaf nodes cover about 400 pixels of ground resolution, and every level-of-detail node covers about 400 times the resolution of the node.

The --resolution parameter sets the resolution of the leaf nodes, in meters. This resolution must be set to the resolution of the reference 3D model. In the current version of ExportUniqueMesh, the quadtree has a uniform depth. In other words, it is assumed that all input tiles have the same resolution.

# ExportUniqueMesh: post-processing tool for generating city-scale 3D models with complete level-of-detail structure

## Output

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The output SRS and origin must be specified and can be chosen independently of the settings of the ContextCapture project.

The fill color setting is similar to the "Color of untextured regions" setting of a reconstruction in ContextCapture Master.

## Processing

The program does not use GPU computing. Any available computer with a powerful CPU can be used.

Only one instance of the program should run on one computer, because one instance of the program uses all the processor cores of the computer.

Thanks to the files written in the cache directory, the process can be resumed from its current progress if it is interrupted by a computer failure, simply by running the program again with the same parameters. Inconsistent results will be obtained if the program is run with different parameters after an interruption without clearing the cache directory.

The program can run on several computers in parallel. The same parameters (tile list, tiling structure, output format/options, etc) and the same - or an equivalent - output and cache directories must be given to the different computers.

Even if the program is run on several computers in parallel, only one computer writes the output files in the last processing step: the first computer where the program was started. It is recommended to choose the computer with more I/O performance for the output directory.

Increasing the number of computers too much will lead to an I/O bottleneck. Using more than 10 computers to create a same 3D model is unlikely to be useful.

## Licensing

The program requires activation by a ContextCapture license, allowing the Engine component.

## Output

The files created in the cache directory are for internal use only (resuming and parallelization capabilities). The output 3D model database is created in the output directory.

## Formats

The --format parameter can be chosen among the values below:

- Formats natively supporting level-of-detail:
  - "3SM" (Bentley Scalable Mesh and Web-Ready Scalable Mesh)
  - "3MX" (ContextCapture 3MX)
  - "Cesium 3D Tiles"
  - "ESRI i3s" (ESRI i3s scene database)
  - "Google Earth KML"
  - "SpacEyes3D" (SpacEyes3D Builder layer)

# ExportUniqueMesh: post-processing tool for generating city-scale 3D models with complete level-of-detail structure

## Output

---

- "OSGB" (OpenSceneGraph binary)
- "LODTreeExport"
- "S3C" (Smart3DCapture S3C)
- Formats only supporting single-resolution meshes:
  - "OBJ" (OBJ wavefront)
  - "FBX" (Autodesk FBX)
  - "Collada"
  - "STL" (StereoLithography)
  - "OpenFlight"
  - "Legacy" (Collada and XML files, read more below)

To know more about the different formats, please refer to the ContextCapture User Manual.

For formats only supporting single-resolution meshes, the level-of-detail structure is materialized by the file structure described below.

## Level of Detail Structure

No matter the output format, the structure of the output database is the same. The nodes of the quadtree will be named with a "key" text string indicating their level and their position in the tree in a very concise way.

For example, for a quadtree, at each level,

- 0 means the south-west child quadrant,
- 1 the south-east child quadrant,
- 2 the north-west child quadrant and
- 3 the north-east child quadrant.

For octrees and adaptive trees, there can be up to 8 children for each node of the level-of-detail tree.

A directory level is added every three levels of the LOD tree to limit the number of files in a same directory.

Hence, the names of the output files will be as follows (.ext denotes the format-specific extension):

root.ext

Data/0.ext

Data/1.ext

Data/2.ext

Data/3.ext

Data/00.ext

Data/01.ext

...

Data/000.ext

...

Data/000/0000.ext

Data/000/0001.ext

# ExportUniqueMesh: post-processing tool for generating city-scale 3D models with complete level-of-detail structure

## Output

---

Data/000/0002.ext

Data/000/0003.ext

...

Data/333/3333.ext

...

An example for a node at level 11 of the quadtree: Data/012/321/220/01232122023.ext

For some formats, the nodes having a same parent node are stored in a single file. For example, Data/10t3.ext contains the four children of node 1.

For some formats (for example, 3MX), the root node is saved in the Data subdirectory and the output directory contains a format-specific scene file containing relevant metadata (e.g., SRS) and a reference to the root node.

Warning: ExportUniqueMesh does not produce all nodes of the level-of-detail tree: it omits to save the empty nodes, if these nodes have an empty subtree.

## Legacy format

This format is maintained only for compatibility with older versions of ExportUniqueMesh. We recommend to use other formats for your new work. Each node consists of three files:

- a .dae file representing a 3D mesh in Collada format, with vertex and texture coordinates.

Vertex coordinates of the 3D mesh are expressed in the output spatial reference system specified by the --outputSRS option, relatively to the origin given in the .xml metadata file described below.

- a .jpg file containing the texture map of the Collada mesh.

There is exactly one texture map for each 3D mesh. The size of the texture map can be different for different nodes. The typical size of the texture map largely depends on the parameters of the output quadtree structure.

- a .xml file, in XML format, containing some metadata of the 3D mesh.

An example of this XML file is given below:

```
<Node>
  <Min>
    <x>152801.431926</x>
    <y>6578301.25849</y>
    <z>-3.76320197071</z>
  </Min>
  <Max>
    <x>154597.742193</x>
    <y>6580000.81617</y>
    <z>65.7186735891</z>
  </Max>
  <Origin>
    <x>153699.58706</x>
    <y>6579151.03733</y>
    <z>30.9777358092</z>
  </Origin>
</Node>
```

## ExportUniqueMesh: post-processing tool for generating city-scale 3D models with complete level-of-detail structure

### Output

---

The Origin tag indicates the position in the output spatial reference system relatively to which 3D mesh coordinates are expressed.

The Min and Max tags indicate the extent of the 3D mesh, in the output spatial reference system.

Warning: the extent of the 3D mesh may exceed the theoretical extent of the node in the quadtree, because the 3D mesh includes some small overlap and/or skirts to hide cracks in the 3D model between regions rendered with different level-of-detail.

# 15

## 3MX Web Deployment

### How to produce for web viewing

If you wish to produce a scene for web viewing, you have to choose 3MX as the export format. You can do this in the Production dialog of ContextCapture Master (see image below).

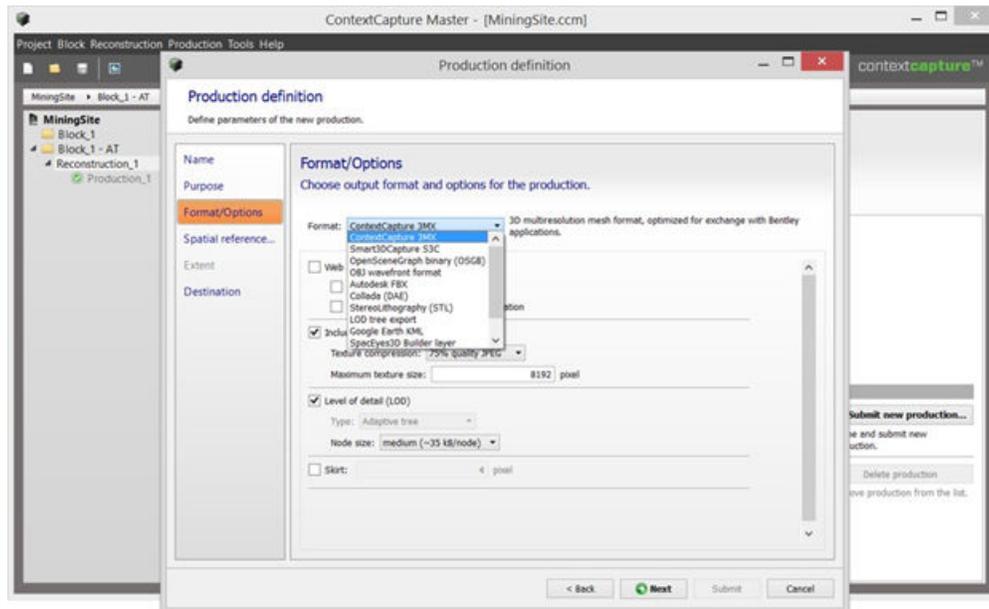


Figure 116: Choosing the web format at production time.

### The web format

The 3MX format is the format dedicated to web publishing, but not only. The intended usage of 3MX is threefold:

- Online distribution, by using our new ContextCapture Viewer.
- Interoperability with other Bentley Systems products, such as MicroStation.
- Interoperability with 3rd party applications (3D GIS).

Since web publishing is not the only possible use of a 3MX production, certain options not suited for web are made available at the production level. You should choose the most appropriate configuration for your purpose; see the next section for more details.

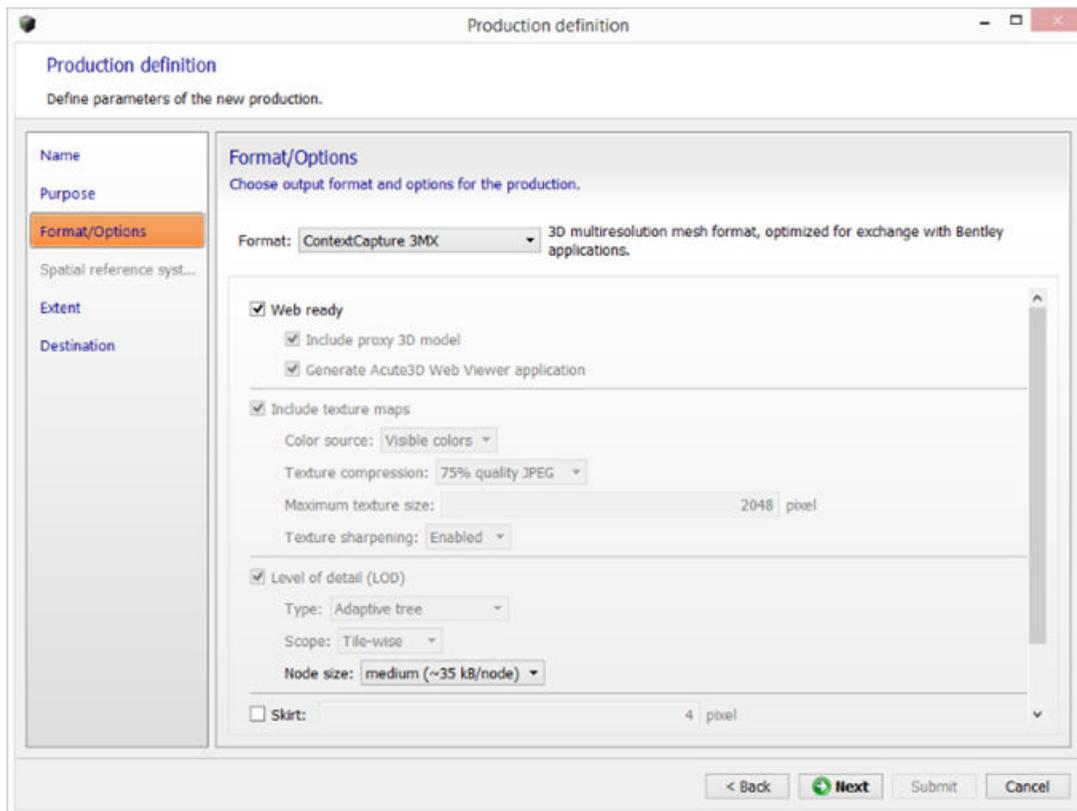
## 3MX Web Deployment

How to produce for web viewing

If you are interested in knowing more about 3MX, we refer you to the 3MX specification documentation in the document directory (3MX Specifications.pdf).

### The production options

When producing in 3MX format, you can set a number of options, shown in the screen capture below:



As the 3MX is an exchange format with a broader use than just web publishing, certain options are not appropriate for web use. Inversely, exporting for web requires a certain set of options that are not necessarily needed if the intent is interoperability with other software.

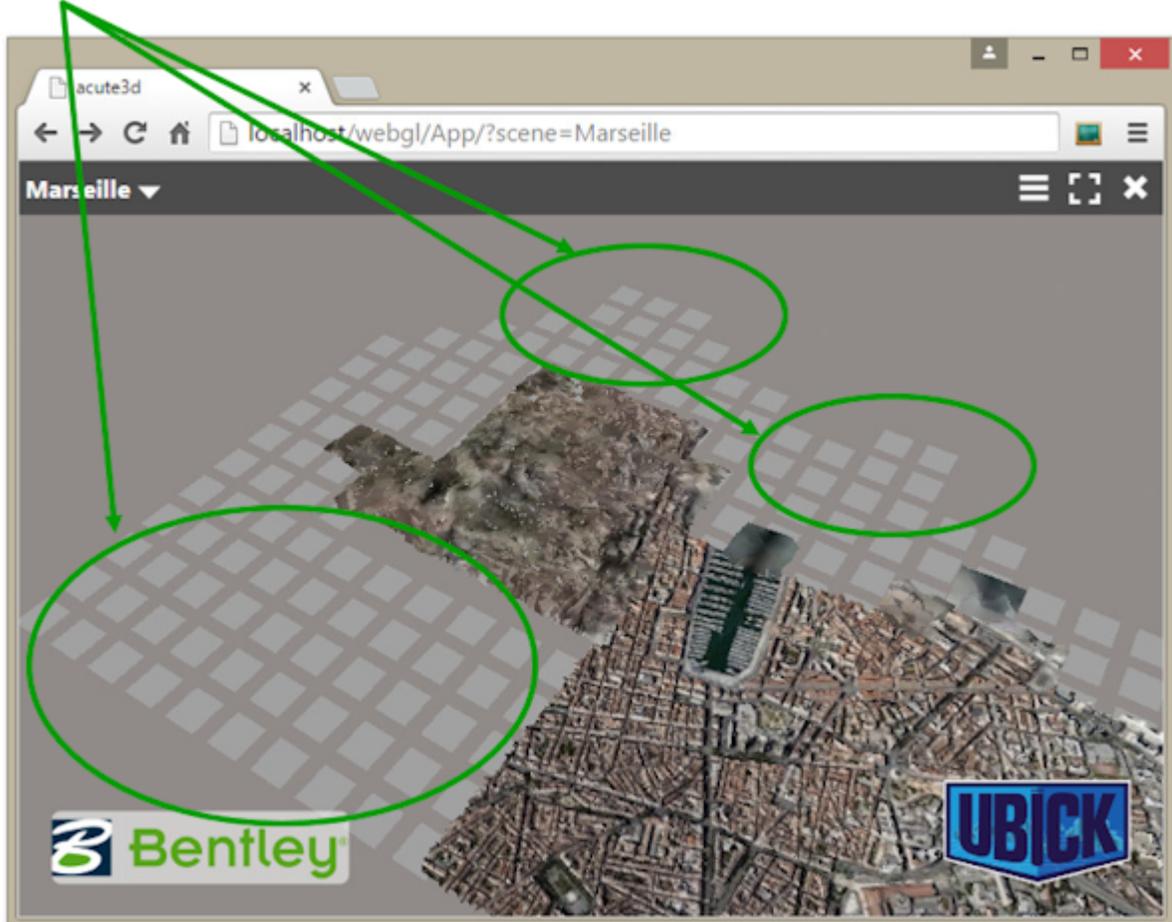
When choosing the export options, you should consider what will be the main use for your production.

1. The first option is the “Web ready” flag. When this flag is checked, all settings are optimized for a web production. In addition, the production will include the ContextCapture Web Viewer application, so all is ready for a (quasi-)direct use of the production on a website. Unchecking the “Web ready” can still produce a valid web scene, but you have to take more care on setting the appropriate options.
2. “Include proxy 3D model” creates a geometry indicating the footprint of your scene (see image below). This geometry will be shown while waiting for the true geometry to be loaded. If you uncheck this option, nothing will mark the area where the scene is.

## 3MX Web Deployment

How to produce for web viewing

### Proxy models



3. The “Generate ContextCapture Web Viewer application” option produces the ContextCapture web application next to the 3D scene in 3MX format. The application is used to display the scene in a browser, as described in the “[How to deploy the production](#) (on page 241)” section.
4. If “Include texture maps” is checked, the model textures will be generated, and a single texture will be at most of the “maximum texture” size. If “Include texture maps” is unchecked, no texture will be generated for the model. For web viewing, it is important that textures should not surpass 2048 pixels in size (either width or height).
5. “Keep untextured regions” will generate geometry for areas that were reconstructed, but with no texture recovered from the images. If unchecked, the untextured regions will be replaced by holes.
6. The “Level of detail” technology permits the decrease in the complexity of the scene as it moves away from the viewer. If this option is checked, simplified versions of the scene are generated alongside the most refined reconstruction. Moreover, the geometry is split into parts that are faster to load. The node size indicates how big a geometry part should be.
7. Lastly, the “Skirt” option adds an additional border around each geometry node and around each tile, to avoid cracks between the different parts of the mesh. The skirt is not tangent to the 3D model: it lies in the boundary of the 3D region of the node, and it is oriented towards the interior of the 3D model.

## The production reference system

## 3MX Web Deployment

How to produce for web viewing

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For a georeferenced project, choosing the spatial reference system is important for the web application. The spatial reference system impacts the 3D visualization and the coordinates' management in the web application.

You must select a spatial reference system with metric coordinates, appropriate for 3D visualization. We recommend to use ENU systems, or standard UTM/WGS 84 projections.

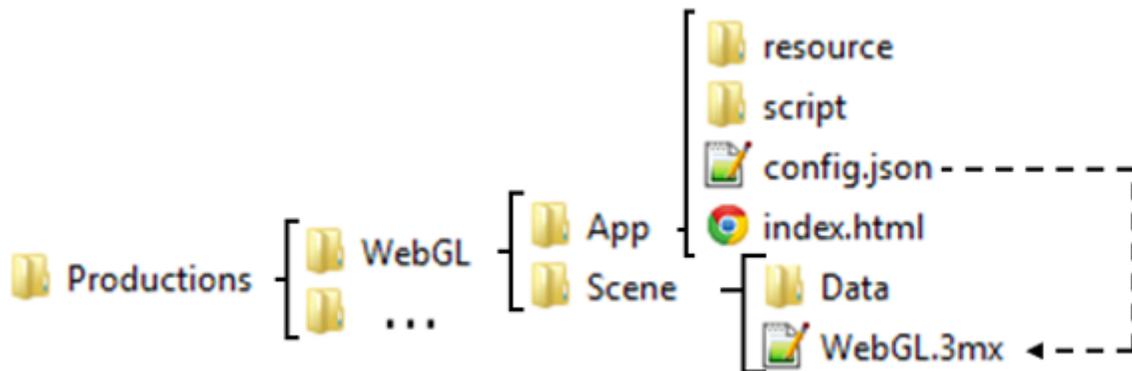
For coordinates' management, the ContextCapture web application has its own, fairly limited, spatial reference system (SRS) database. The web viewer SRS database is limited to ENU systems and standard EPSG projections, and does not handle vertical datum. The Z value will be displayed as is in the web application, in the general case using the ellipsoid as reference.

If you want the web application to display orthometric heights, you should produce the 3MX with a spatial reference system with a suited vertical datum (eg. EGM96).

### The production result

When using the default settings, a 3MX production is a web-ready production. In this case, the production result is split in 2 parts.

First, the scene in 3MX format is in the Scene folder, as you can see in Figure 3. The scene is organized in a tree-like structure, very similar to the native S3C scene. The root of the scene is the Scene/YourProductionName.3mx file. In Figure 3, the production is called WebGL, so the root 3MX file is Scene/WebGL.3mx. If you wish to know more about the 3MX organization, we refer you the 3MX specification documentation.



A second folder is included in a default 3MX production: the App folder. This contains the ContextCapture web application. Note that the App folder exists only if the option "Generate WebGL application" is checked at production time.

The files you need to care about in the App folder are:

- The index.html file. It is the root file for the application
- The config.json file. This file points to the Scene/YourProductionName.3mx file, so the ContextCapture web viewer knows what scene to load.

### Warning

If you double click on index.html file, you will not see the application. Your preferred browser should open the file and display a warning message like the one shown in the image below. This is due to browser security settings.

## 3MX Web Deployment

How to produce for web viewing

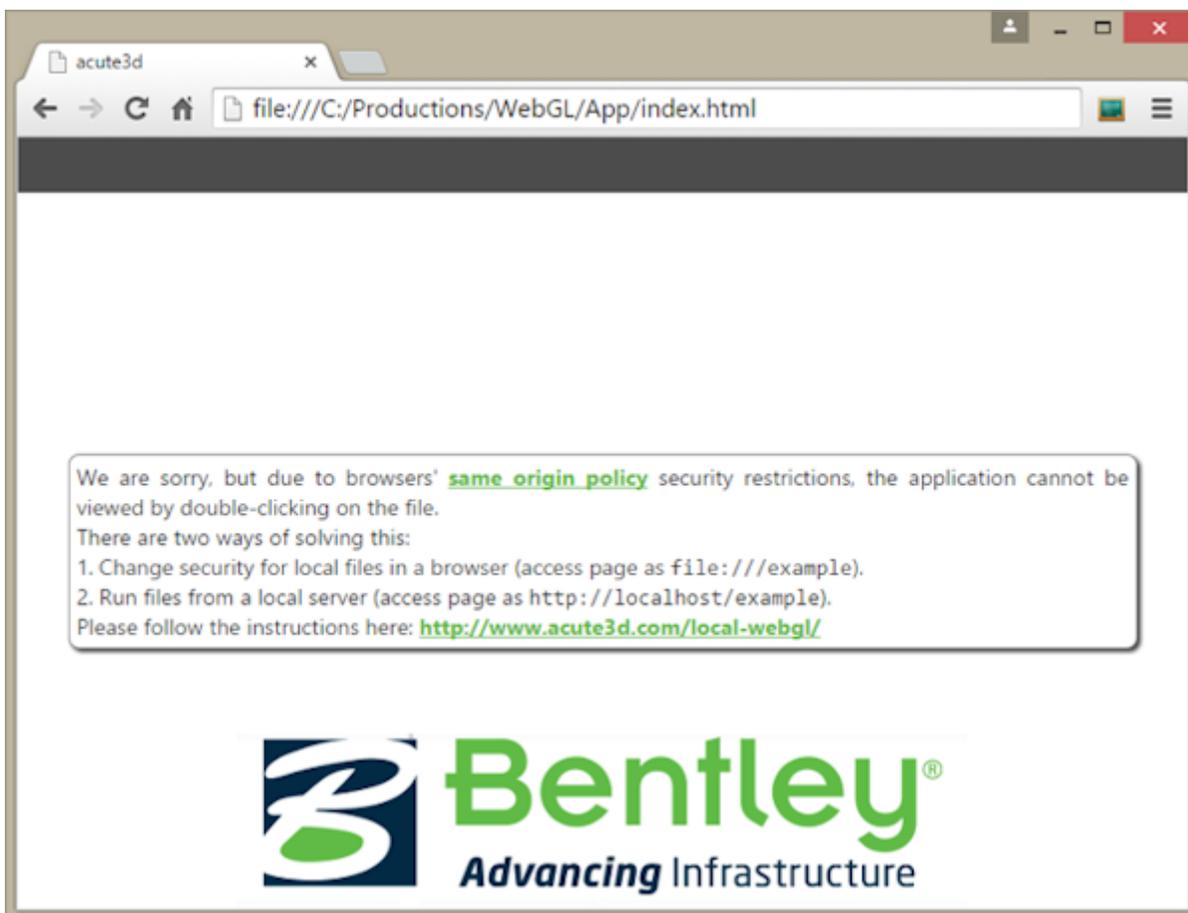


Figure 117: Double clicking on the web application (index.html) shows a warning in the browser, because of the same origin policy all browsers implement.

Displaying locally your WebGL production requires an amount of technical expertise. If you only wish to verify your 3MX production, you can open it with the ContextCapture Desktop Viewer. You just need to choose 3MX as the type of file to open, and navigate to your Scene/YourProductionName.3mx file (see screenshot below).

## 3MX Web Deployment

How to configure the web application and scene

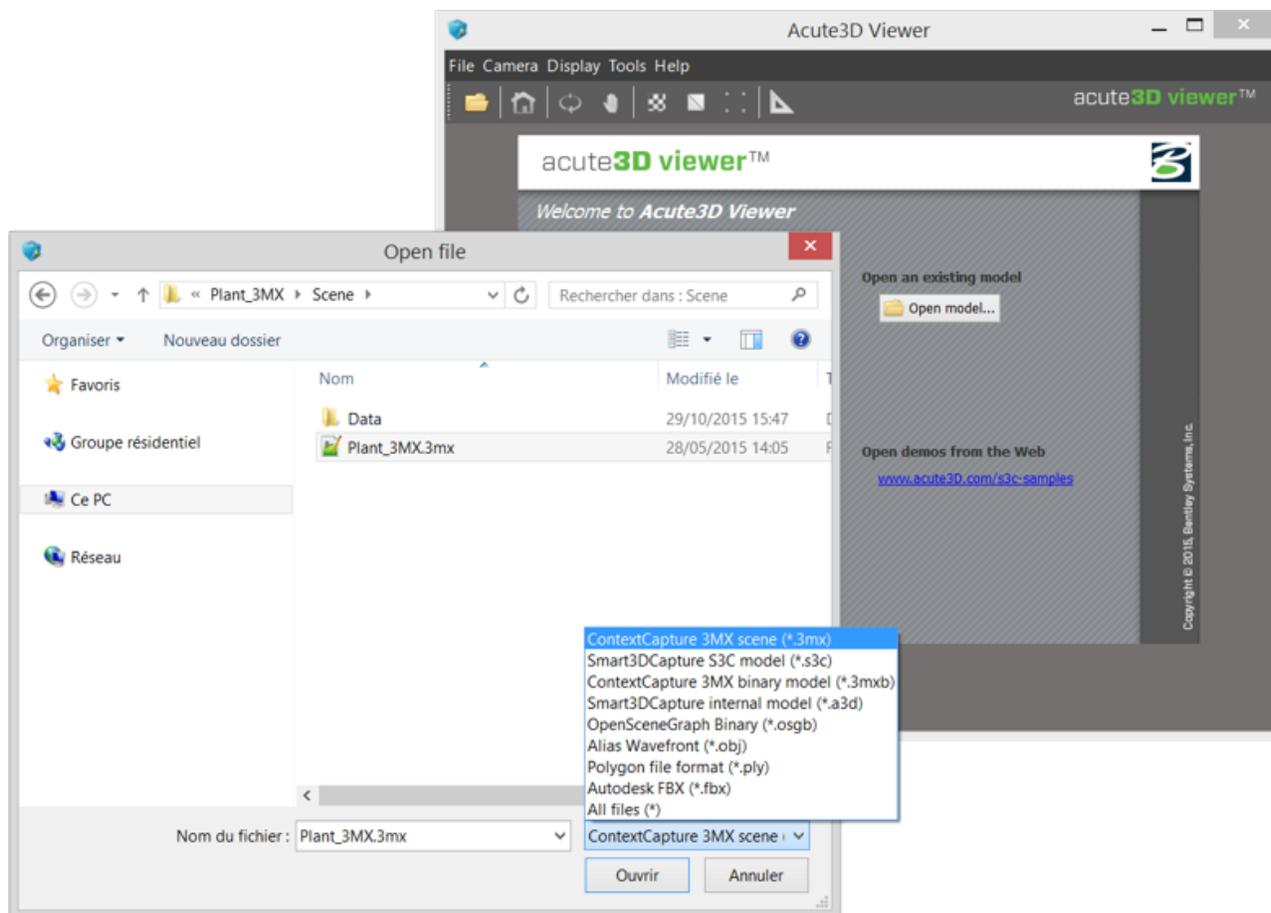


Figure 118: Opening a 3mx file in ContextCapture Desktop Viewer

If you do however need to open the ContextCapture Web Viewer locally, please see "[Appendix A: View the ContextCapture Web application locally](#) (on page 253)" for step-by-step instructions.

## How to configure the web application and scene

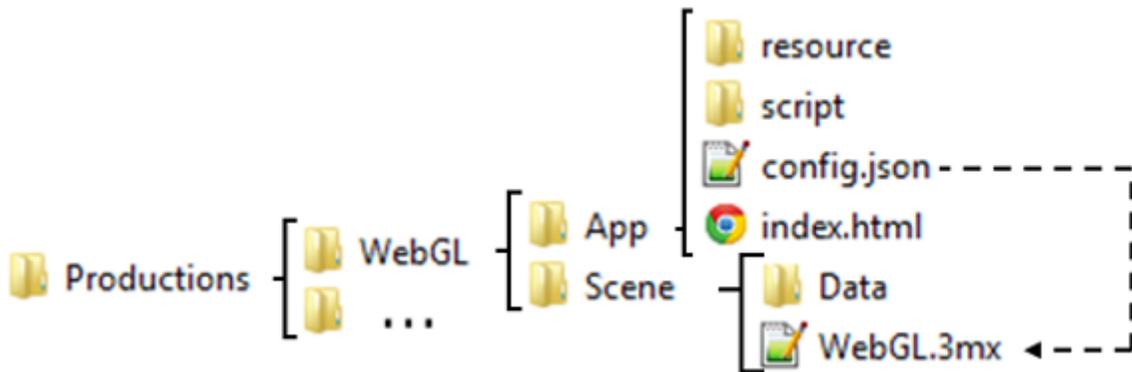
A default WebGL production contains 2 different sets of data, each in a separate folder:

- The produced scene, in 3MX format, is in the Scene folder
- The WebGL application, used to render the scene in a browser, is in the App folder.

## 3MX Web Deployment

How to configure the web application and scene

---



### Configuring the 3MX

There are 4 scene-specific pieces of data used by the web application, and that you should take care to define:

- Your logo, which will be displayed by the 3D viewer.
- A placeholder image that is shown by the web viewer whenever the 3D display is deactivated or there is an error. This image should represent the 3MX scene.
- The scene name and description, contained by the Scene/YourProduction.3mx and shown in the web viewer.
- The default navigation mode

All 4 pieces of data are contained in the Scene folder.

#### Add your logo

Your logo will be displayed by the ContextCapture Web Viewer. To add it, you need to replace the image logo.png contained in the Scene folder with your own logo. You should preserve the name of the image, and use a small-sized logo, as the ContextCapture Web application does not resize your logo.

#### Add the scene image

The scene image is shown by the web viewer whenever the 3D display is deactivated or there is an error. This image should represent the 3MX scene. To add it, you need to replace the image placeholder.jpg contained in the Scene folder with your own logo. Note that you should preserve the name of the image.

#### Add the scene description

The scene name and description are shown in the ContextCapture Web viewer. The scene name and description can both be defined in the Scene/YourProduction.3mx file. You can open the file with a text editor, and replace the name and description tag.

For example, a production called “YourProduction” will have the default root YourProduction.3mx look like this:

```
{
  "3mxVersion": 1,
  "name": " YourProduction",
  "description": "Scene generated by ContextCapture, copyright <a href='http://www.bentley.com' target='_blank'>Bentley</a>",
```

## 3MX Web Deployment

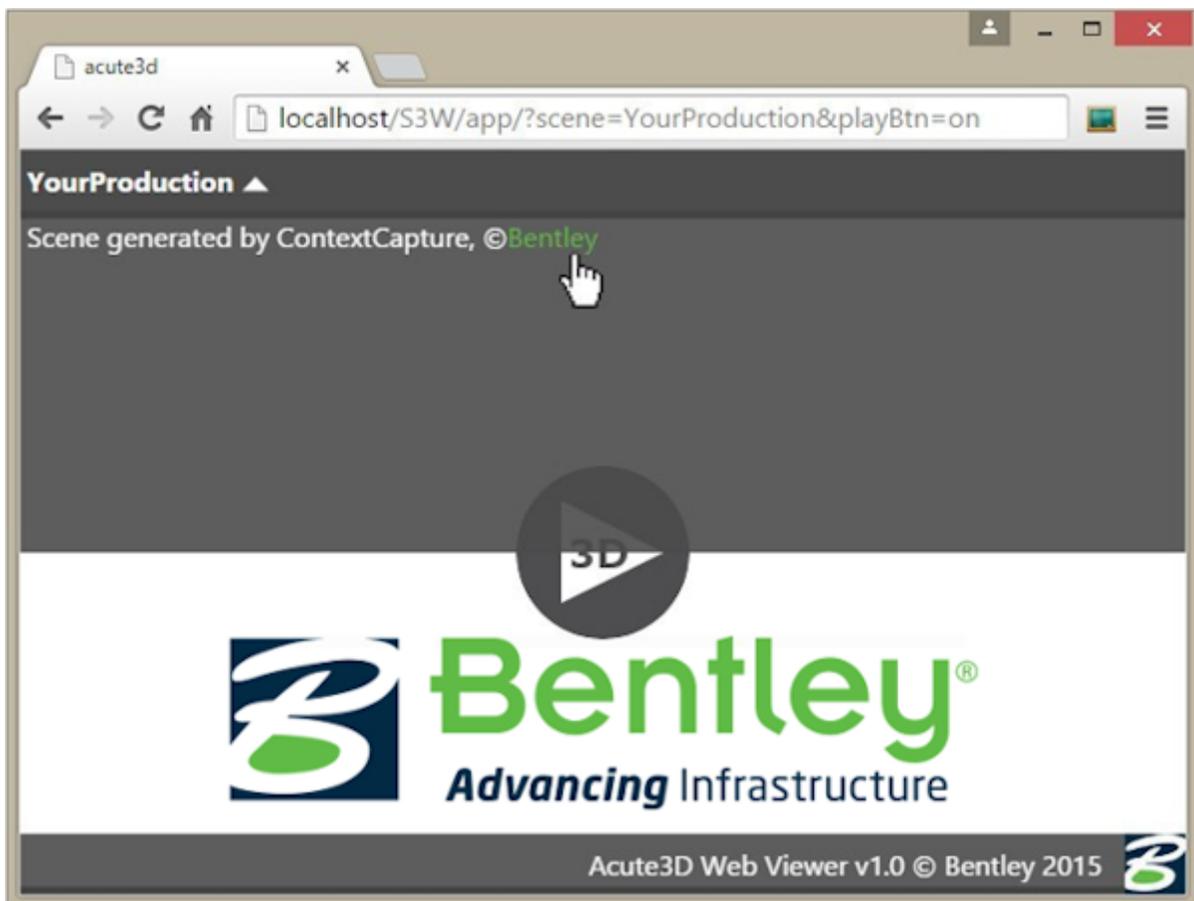
How to configure the web application and scene

```
"logo": "logo.png",
"sceneOptions": [{"navigationMode": "PAN"}],
"layers": [
{
"type": "meshPyramid",
"id": "mesh0",
"name": "YourProduction",
"description": "Model generated by ContextCapture, copyright <a href='http://www.bentley.com' target='_blank'>Bentley</a>",
"SRS": "- given SRS -",
"SRSOrigin": [0,0,0],
"root": "Data/YourProduction.3mxb"
}
]
}
```

To customize the message shown in the web viewer, you have to modify the name and description tags, shown in bold characters. The web application supports html tags in the scene description. For example, this tag:

```
"description": "Scene generated by ContextCapture, &copy;<a href='http://www.bentley.com' target='_blank'>Bentley</a>",
```

will be shown in the application like this:



## 3MX Web Deployment

How to configure the web application and scene

---

**Note:** be careful with quotation marks. Because they signal the end of a tag, quotation marks should not be used inside a scene description. For example, this code will produce an error:

```
Error: "description": "Scene generated by ContextCapture, copyright <a href="http://www.bentley.com" target="_blank">Bentley</a>"
```

If you do wish to use quotation marks in your description, please use either ' or \":

```
OK: "description": "Scene generated by ContextCapture, copyright <a href=\"http://www.bentley.com\" target=\"_blank\">Bentley</a>"
```

### Set the default navigation mode

The 4th setting you can define for a scene is the navigation mode. Just as the scene name and description, the navigation mode is defined in the root 3MX: ../Scene/YourProduction.3mx file. You can open the file with a text editor.

To define the default navigation, you need to modify the tag sceneOptions. The line

```
"sceneOptions": [{"navigationMode": "PAN"}]
```

sets the default navigation to PAN. The other option you can use is:

```
"ORBIT"
```

### Configuring the web viewer

The web viewer can be open in any browser – please see "[How to deploy the production](#) (on page 241)" for the necessary settings. The browser should show something similar to the image below:

## 3MX Web Deployment

How to configure the web application and scene

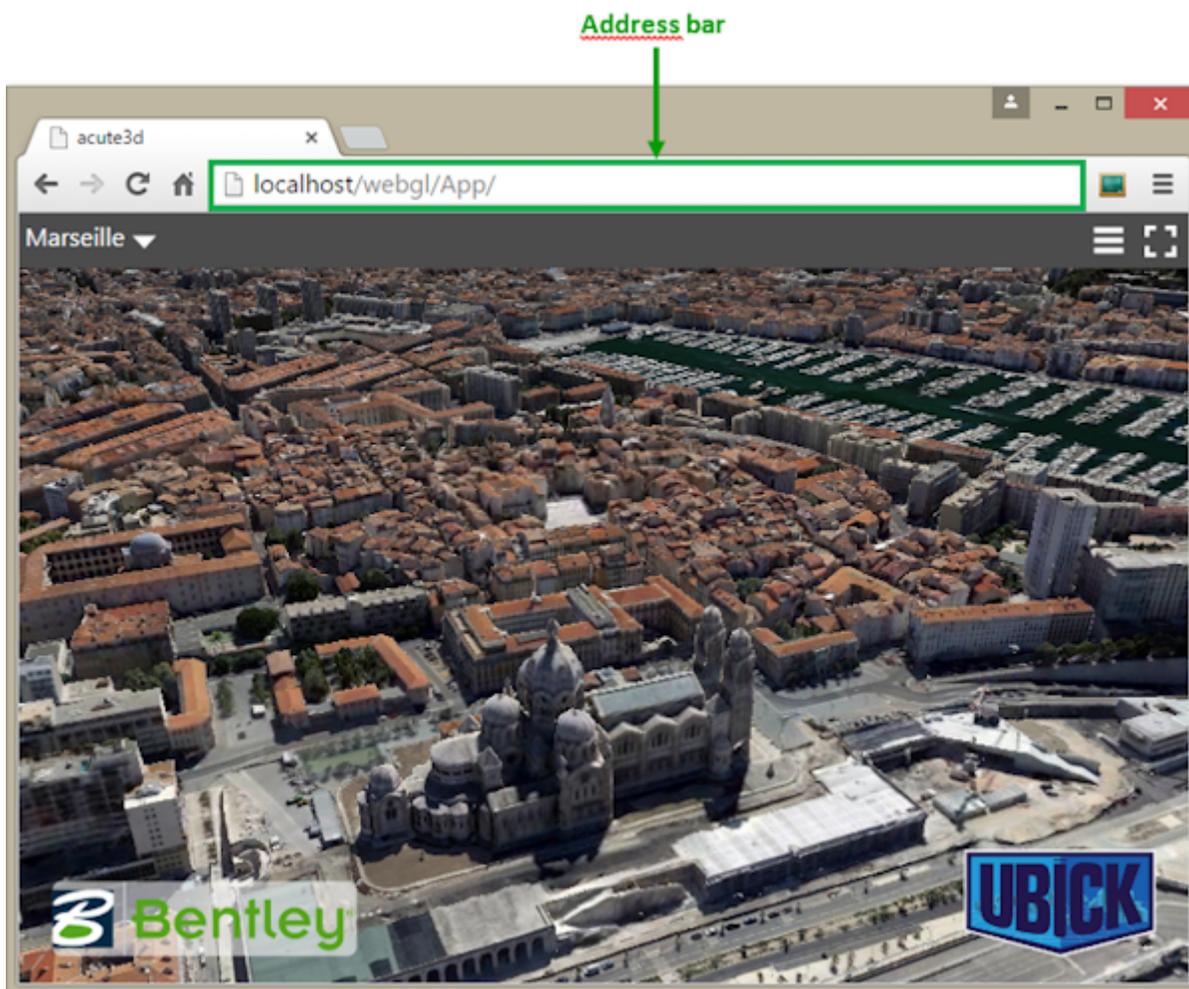


Figure 119: WebGL viewer shown in a browser, by using a local server.

### Address bar parameters

The first way of configuring the web viewer is through address bar parameters. The address bar is the place where we type the address for a chosen website, as indicated in the image above.

3 options can be passed to the web viewer by using the address:

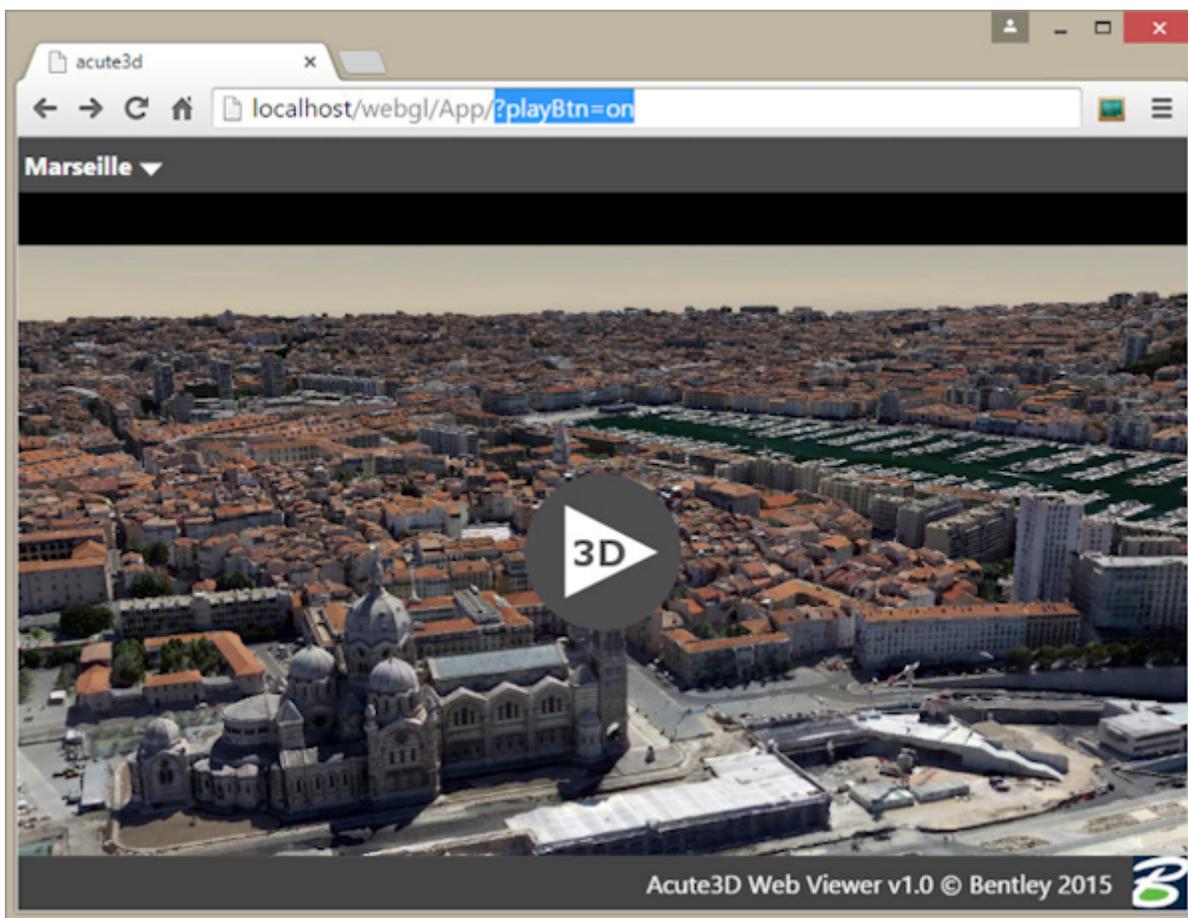
- Add a play button to the screen. The application waits for the button to be pressed before showing the 3D scene.
- Set the 3D scene to be loaded
- Camera viewpoint

### Add a play button to the screen

The play button screen option is turned on by adding `playBtn=on` to the browser address. The application waits for the button to be pressed before showing the 3D scene. An example of how to do this is shown below:

## 3MX Web Deployment

How to configure the web application and scene



The background image shown under the play button is the scene placeholder image. You can define this image as described in "Configuring the 3MX".

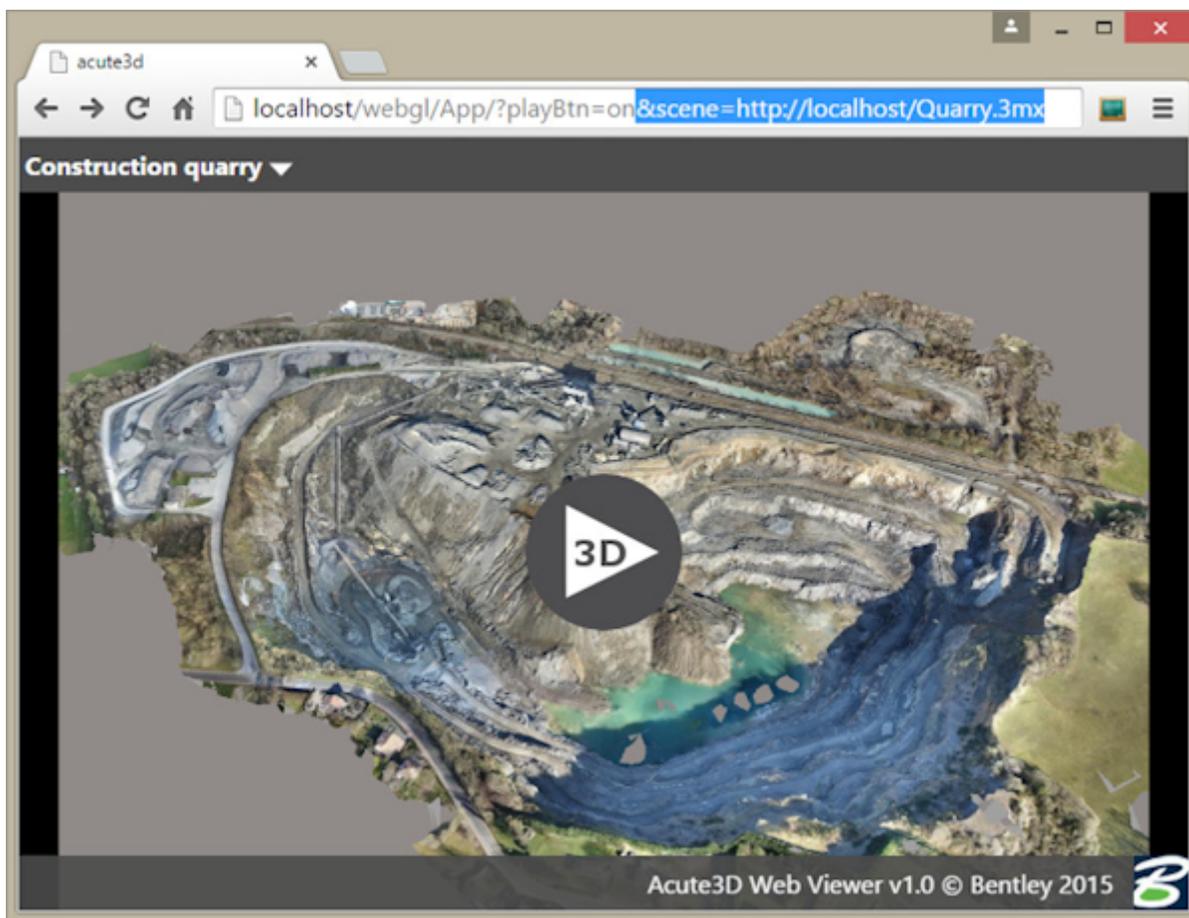
### Set the 3D scene to load

The second option you can define in the address bar is the 3D scene to load. By default, the web viewer is attached to a WebGL production and stores as scene to load the production scene. But you can change the scene by giving the web viewer the web address of a 3mx file. In the example below, the Quarry scene is loaded from the local server by setting the option:

```
scene=http://localhost/Quarry.3mx
```

## 3MX Web Deployment

How to configure the web application and scene



Please note that the address parameter string is preceded by the character ? and the 2 options in the address are separated by the character &.

By exploiting the scene parameter, you can use the same copy of the web application with all your productions. We encourage you to do this for your deployment on the web.

To make easier the access to various scenes, the list of available scenes can all be defined in the web viewer folder, and accessed via aliases. This is done through to the 2nd method of parametrizing the web application — parameters given in the config.json file.

### Set the camera viewpoint

If you want to share with your clients a particular view of your 3D model, special camera parameters in the address bar allow you to do this.

To obtain the current view's camera parameters, you can use the ContextCapture Web Viewer's Link option. Please go to the web viewer's interface section "[Link to the model](#)" (on page 251)" to see more.

### Configuration file parameters

The config.json file is found in the App folder, where App is the web application. The file can be used to define the list of available scenes. A scene can then be accessed via an alias using the address bar scene parameter.

## 3MX Web Deployment

### How to deploy the production

---

By default, the App folder is created during a webgl-ready production, and is stored next to the production's 3D data. In this case, config.json contains the relative address of the 3D data, and will look something similar to this:

```
{
  "URLs": [
    {
      "alias": "YourProduction",
      "scene": "../Scene/YourProduction.3mx"
    }
  ]
}
```

The configuration file is in JSON format. It indicates that there is a single 3MX scene the application can access, with the path to the root 3MX indicated by the "scene" tag. The alias is used to identify the scene by a name.

To create the list of available scenes, you need to modify the file config.json, by adding the web address and an alias for each scene. For example, the file below points to 2 scenes; the first scene is stored on the same server as the web application, while the 2nd one is stored on CloudFront:

```
{
  "URLs": [
    {
      "alias": "Quarry",
      "scene": "../DATA_3D/Quarry/Scene/Quarry.3mx"
    },
    {
      "alias": "Marseille ",
      "scene": "http://deh9aqlpmcj1j6.cloudfront.net/Marseille/Scene/Marseille.3mx"
    }
  ]
}
```

To switch between one scene or another in the web application, it is sufficient to give the alias as scene parameter in the address bar. For example,

- [http://www.acute3d.com/s3c\\_resources/s3w-viewer/?scene=Quarry](http://www.acute3d.com/s3c_resources/s3w-viewer/?scene=Quarry) will show the Quarry scene above, and
- [http://www.acute3d.com/s3c\\_resources/s3w-viewer/?scene=Marseille](http://www.acute3d.com/s3c_resources/s3w-viewer/?scene=Marseille) will show the Marseille scene stored on CloudFront.

If you modify the config.json, you should make sure your modifications can be read by the web application by validating the JSON format of the file. You can do this by copy-pasting the entire content of the file in a JSON validator, such as: <http://jsonformatter.curiousconcept.com/>

## How to deploy the production

Both local and remote 3MX productions can be seen in the ContextCapture Desktop Viewer. This section describes how to set up the web viewer and how to visualize your 3D scenes in a browser.

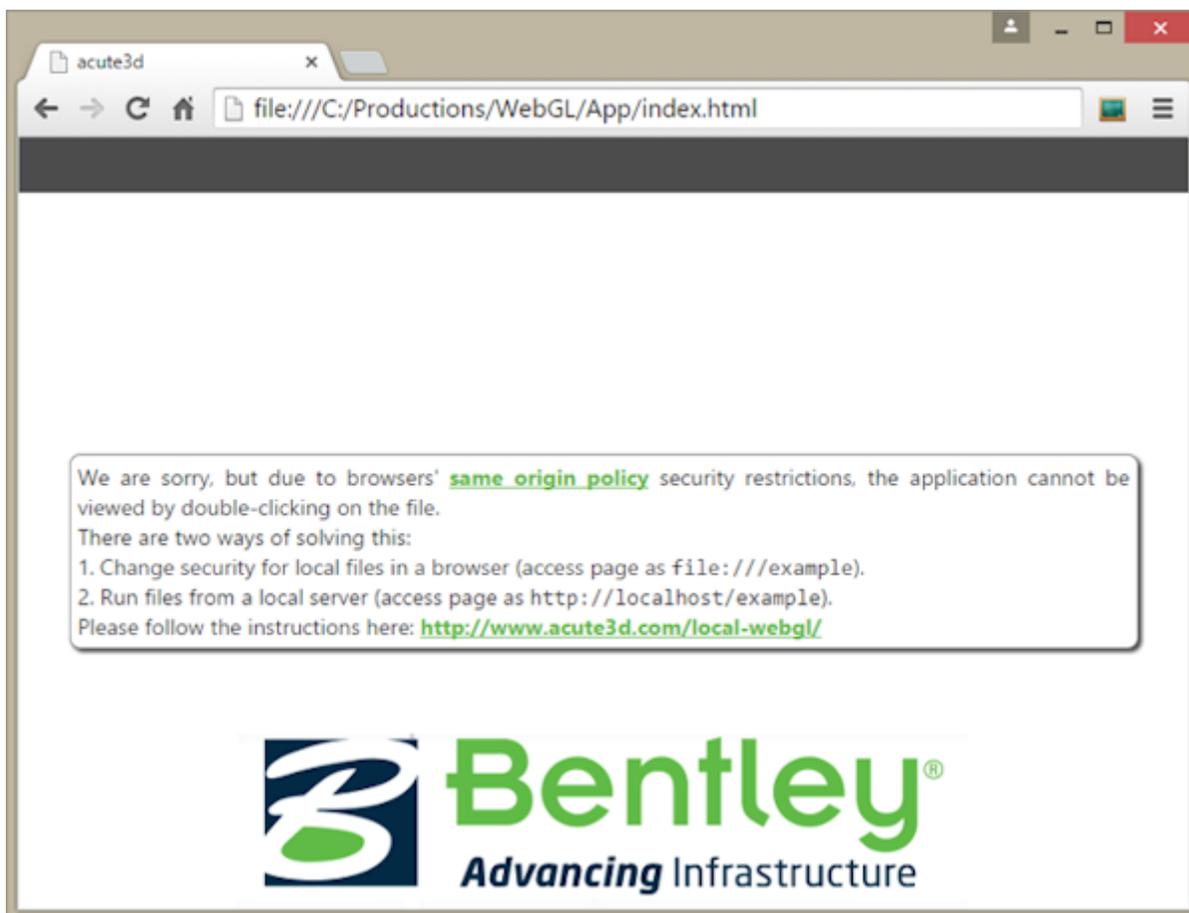
### How to view locally

Due to browsers' [same origin policy](#) security restrictions, loading from a file system will fail with a security exception, as in the screen capture below.

## 3MX Web Deployment

How to deploy the production

---



Bypassing this warning and viewing the ContextCapture Web application locally requires an amount of technical expertise. We recommend you to use ContextCapture Desktop viewer to visualize your scenes locally, and to use your web server for the ContextCaptured Web application.

However, if you do wish to view the ContextCapture Web application directly from your local disk, you can refer to the “[Appendix A: View the ContextCapture Web application locally](#) (on page 253)” instructions.

### Deploy on the internet

There are 2 main options for you to deploy your productions on the internet:

- Use your own server to host both the WebGL application and your productions.
- Use a cloud hosting service for your productions, and only use your own server for the WebGL application.

### Use your own server to host everything

In this case, the production folder can be used without change, if you took care to check the WebGL export options when producing your 3MX scene.

It should be sufficient then to:

## 3MX Web Deployment

How to deploy the production

---

- Copy the production folder on the server, at the appropriate location (next to your webpage index.html file, for example)
- Access the application by going to your\_site/your\_production\_folder\_path/App
- If the page cannot be accessed, it might be necessary for you to change the access rights for your\_production\_folder

The case described above is the simplest use-case, but it also results in the WebGL application being copied every time you create a new production.

Alternatively, you can use the same WebGL application for all your productions. It is sufficient to change its configuration options, as described in the "[Configuring the web viewer](#) (on page 237)" section.

In both cases, the setup should be very similar to your local server setup, if you chose to use one. It is sufficient to copy your data from the local to the remote server, in the same format.

Just remember that the config.json file in your application has to contain relative, and not absolute paths. In other words, scene paths like this: "../Scene/Production.3mx" will work for both the local and remote server. But scene paths like this: "localhost/Scene/Production.3mx" will only work for the localhost.

### Use cloud services for hosting your production

For large scenes, you might wish to host the productions on dedicated cloud servers, such as Azure Blob or Amazon S3. This is entirely possible, and your customers will still be able to access your demos using your site address.

To do this, you need to:

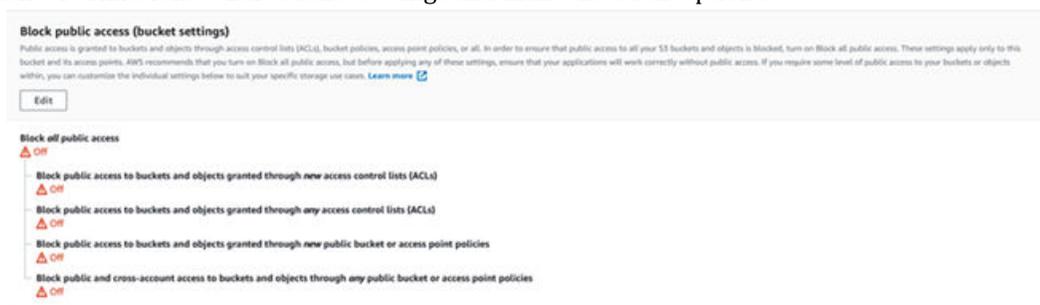
- Load only the production scene onto a cloud server, making sure you enable cross-origin resource sharing for the data.
- Copy the WebGL application on your own server, at the appropriate place.
- Change the config.json file of the application to access the scene hosted on the cloud.
- The demo will be accessible just as before, through your\_site/your\_application\_folder address.

We describe below how to publish the 3MX scene using Amazon S3.

### Hosting on Amazon S3 (cloud front)

Create a dedicated bucket for WebGL, because the bucket needs to have special read/access rights. Make sure that the bucket name is in lowercase if you want to deploy it to the CloudFront.

- Go to bucket Permissions > Edit bucket settings and make the bucket public.



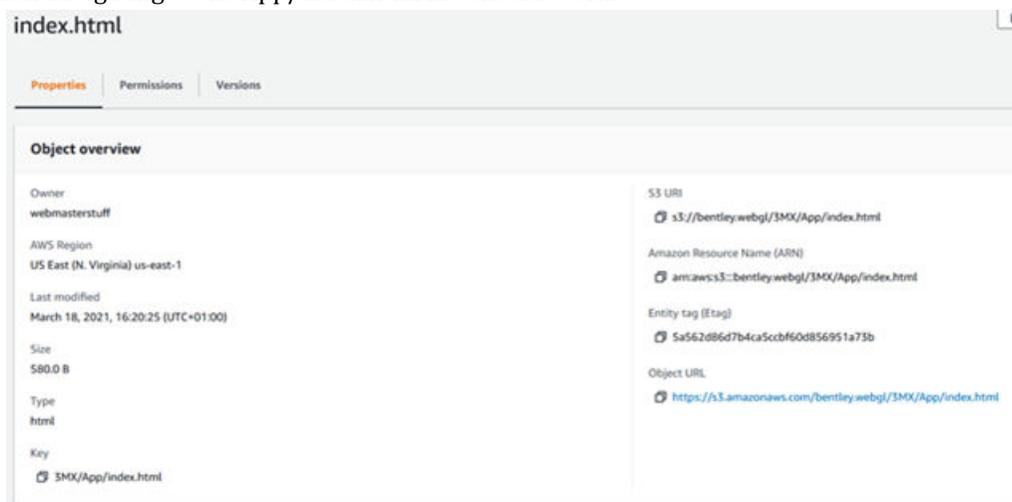
## 3MX Web Deployment

### The ContextCapture Web Viewer Interface

- Change the Bucket policy, written in JSON, as follows (making sure the Resource has the correct Bucket ARN):

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "AllowPublicRead",
      "Effect": "Allow",
      "Principal": {
        "AWS": "*"
      },
      "Action": "s3:GetObject",
      "Resource": "YOUR_Bucket_ARN/*"
    }
  ]
}
```

Any data in this bucket will be public. If the App folder was loaded together with the Scene, using the URL visible when navigating to the App/index.html file should work:



## The ContextCapture Web Viewer Interface

The ContextCapture Web Viewer is the visualization software that allows users to view and navigate ContextCapture models directly on the web. 3D models are loaded and displayed using level-of-detail (LOD), paging and streaming, and users can measure distances and pick GPS coordinates.

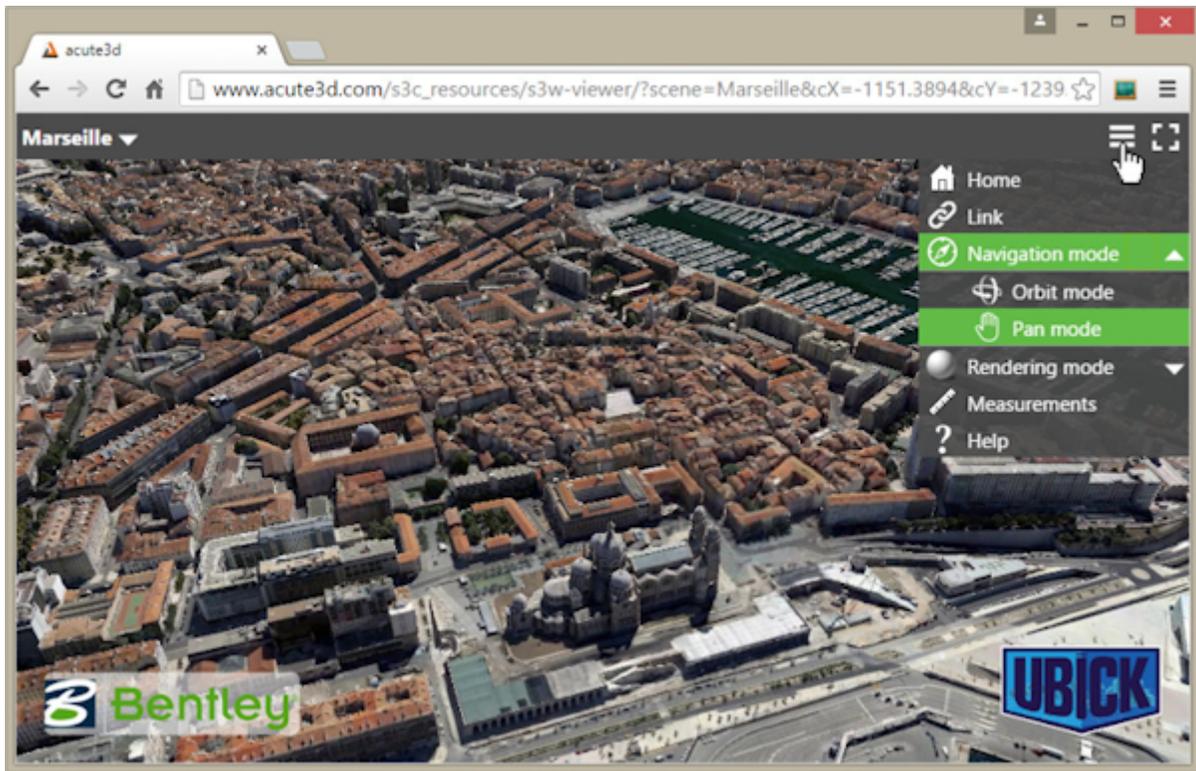
Most of the viewer's options can be accessed by clicking on the Main menu .

### Navigation

There are 2 types of 3D navigation in our web viewer: orbit and pan. You can switch between the 2 modes by going to Menu → Navigation mode (see screen capture below).

# 3MX Web Deployment

The ContextCapture Web Viewer Interface



## Orbit mode navigation

Mouse action	Event
 <p>Left click + drag</p>	Rotate
 <p>Right click + drag</p> <p>Also works with CTRL + Left click + drag, or Mouse wheel scroll</p>	Zoom
 <p>Middle click + drag</p> <p>Also works with SHIFT + Left click + drag</p>	Pan
 <p>Double click</p>	Bring the clicked point to the center of the screen

## 3MX Web Deployment

The ContextCapture Web Viewer Interface

Touch action	Event
 One finger drag	Rotate and tilt
 Two finger pinch	Zoom
 Two finger drag, same direction	Pan
 Two finger rotate	Rotate left and right
 Double tap	Bring the tapped point to the center of the screen

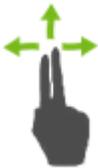
### Pan mode navigation

Mouse action	Event
 Left click + drag	Rotate
 Right click + drag Also works with CTRL + Left click + drag, or Mouse wheel scroll	Zoom

## 3MX Web Deployment

The ContextCapture Web Viewer Interface

Mouse action	Event
 Middle click + drag Also works with SHIFT + Left click + drag	Pan
 Double click	Bring the clicked point to the center of the screen

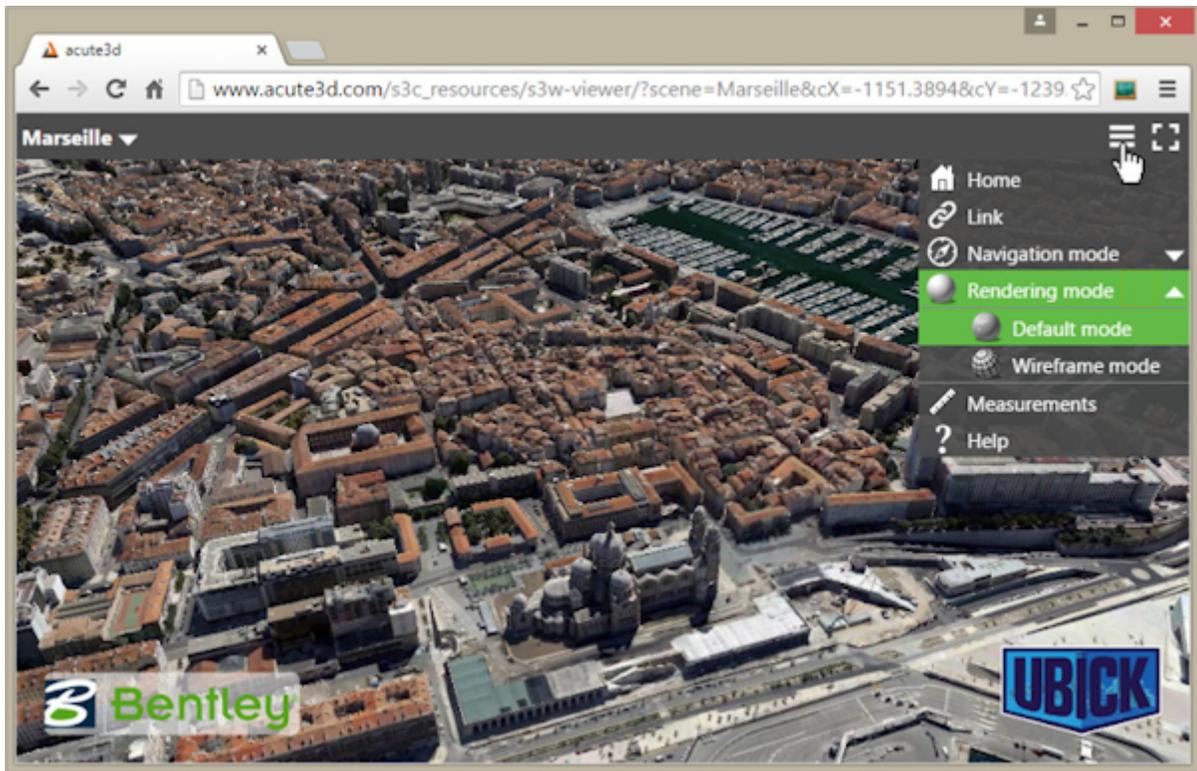
Touch action	Event
 One finger drag	Rotate and tilt
 Two finger pinch	Zoom
 Two finger drag, same direction	Pan
 Two finger rotate	Rotate left and right
 Double tap	Bring the tapped point to the center of the screen

## Rendering

Rendering options can be accessed by going to Menu → Rendering mode (see screen capture below). The wireframe mode can be turned on and off using these options.

## 3MX Web Deployment

The ContextCapture Web Viewer Interface

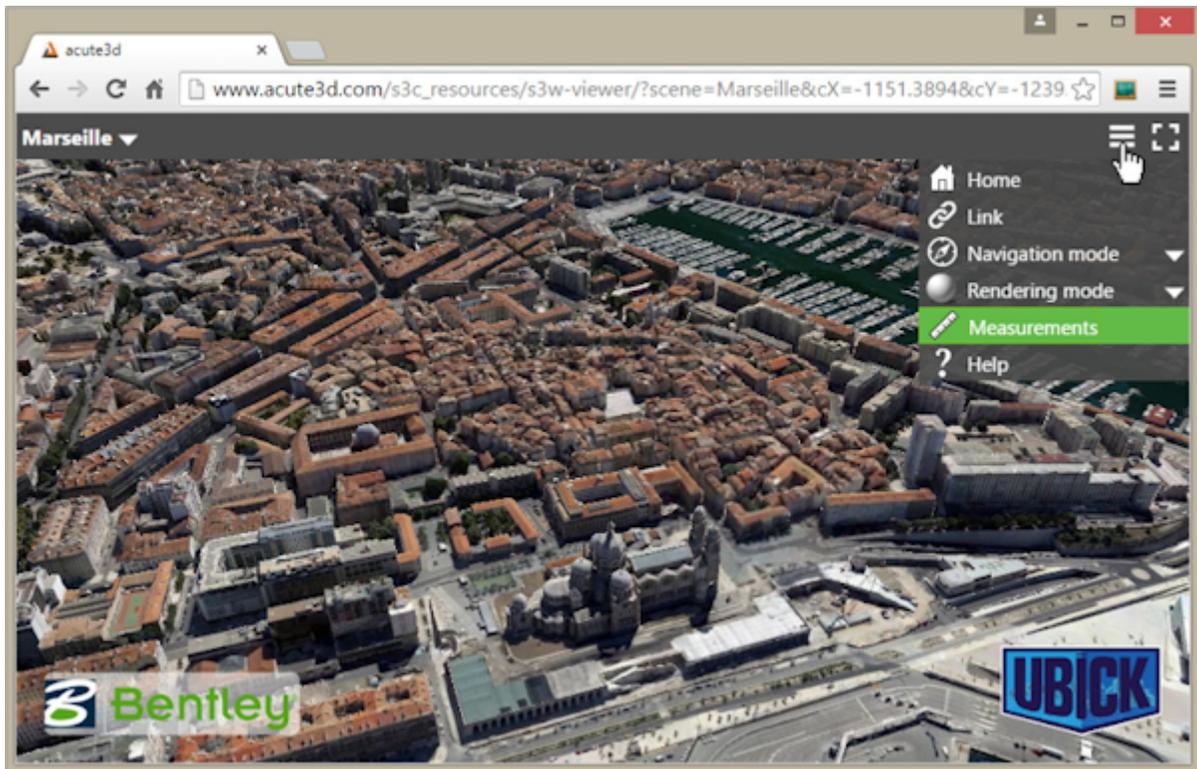


### Measurements and GIS positioning

To measure distances and determine point positions, open the Measurements window by using the Menu → Measurements option.

## 3MX Web Deployment

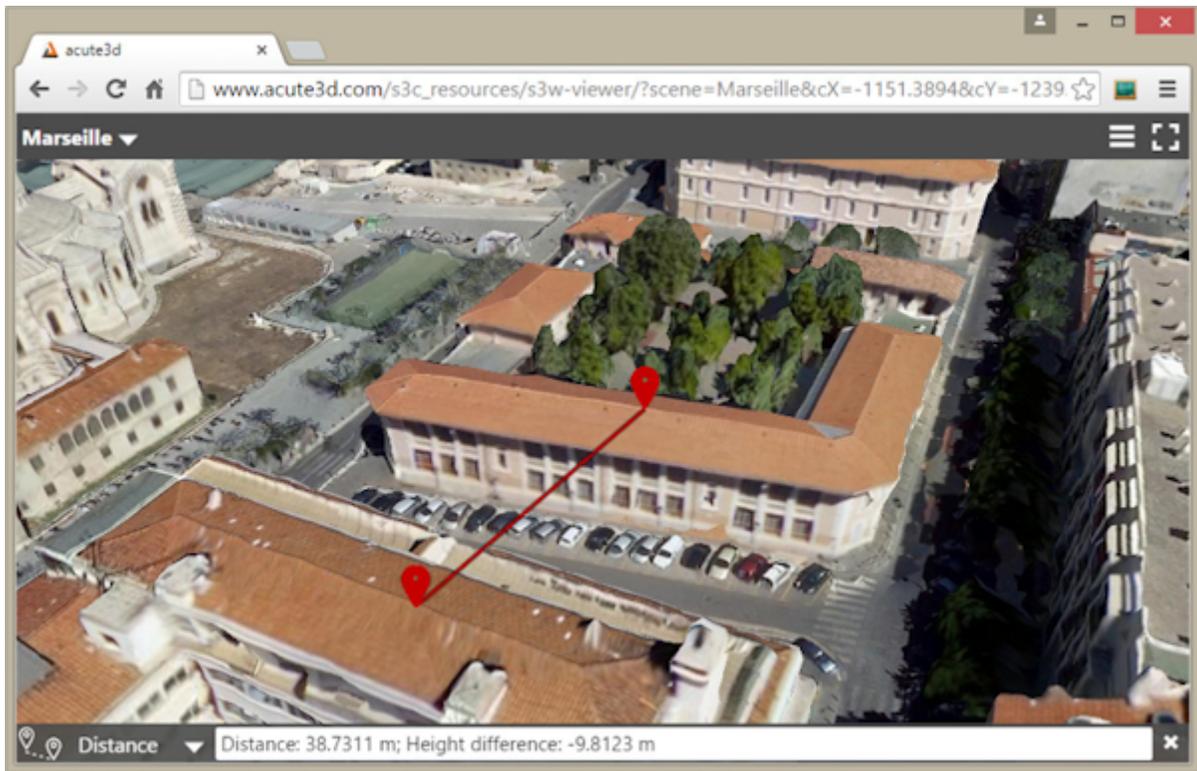
The ContextCapture Web Viewer Interface



If the model is georeferenced, then GPS coordinates are shown in the selected spatial reference system, as well as altitude, and distances are indicated in meters; otherwise distances and positions will be relative to the spatial reference system of the 3D model.

## 3MX Web Deployment

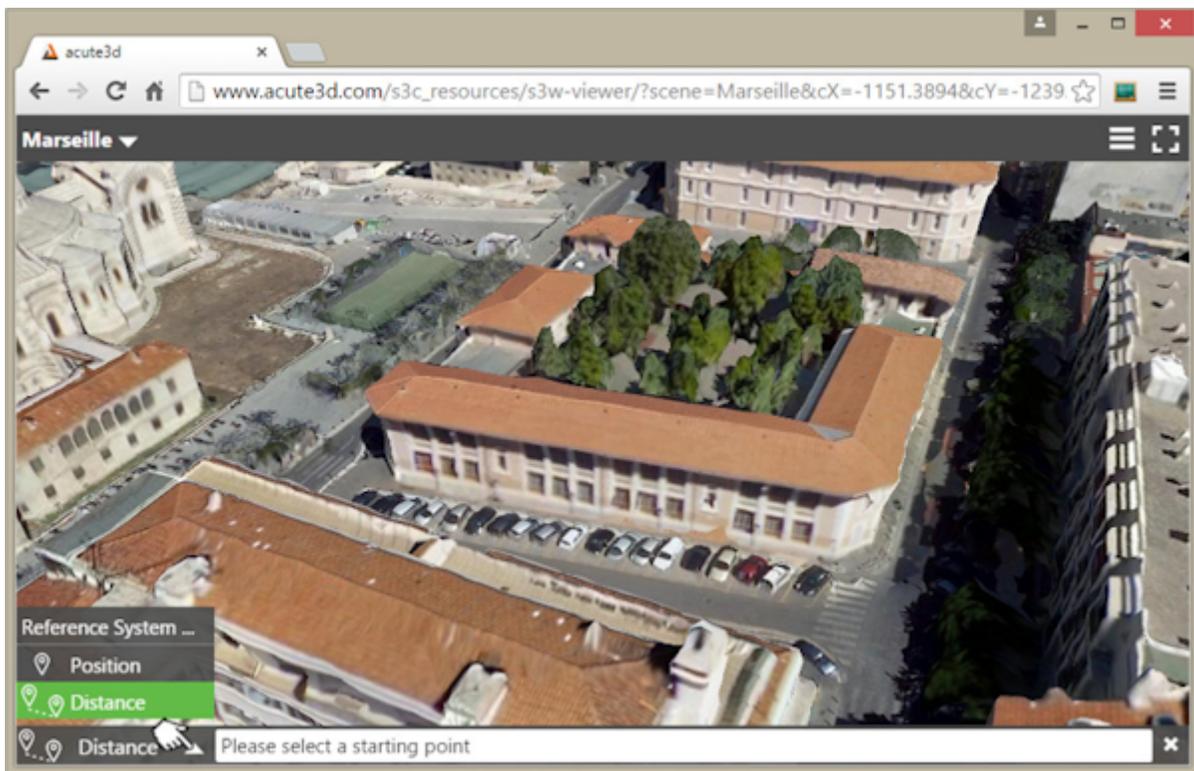
The ContextCapture Web Viewer Interface



You can change the spatial reference system by clicking on the Measurements window options, and by choosing "Reference System ..." (see screenshot below).

## 3MX Web Deployment

The ContextCapture Web Viewer Interface



### Link to the model

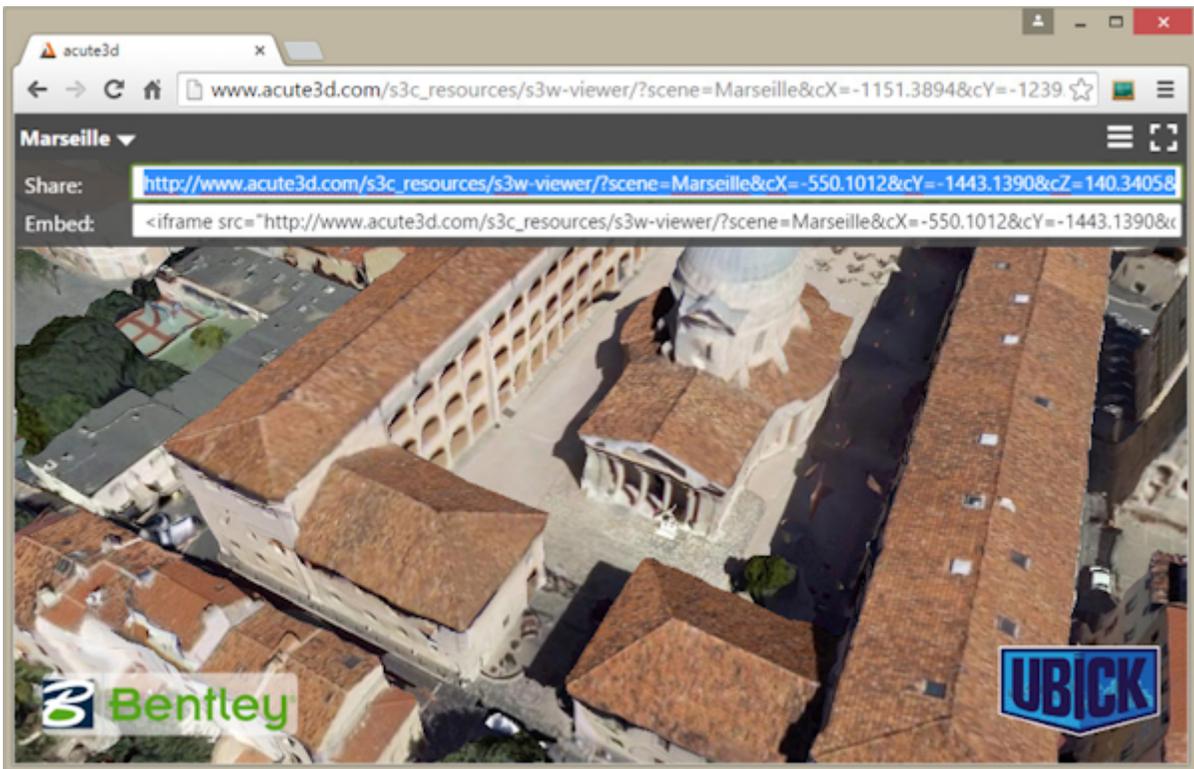
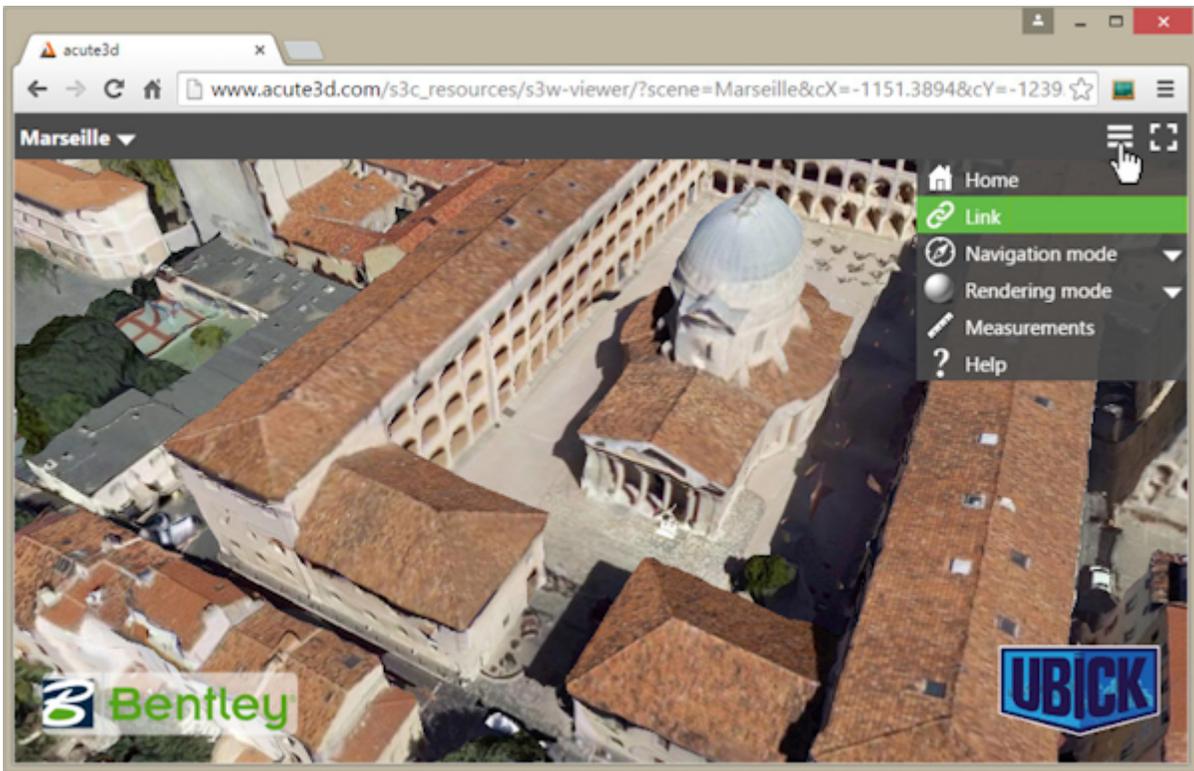
If you want to share with your clients a particular view of your 3D model, you can do this in the ContextCapture Web Viewer by going to Menu → Link. This will open up a window with 2 links: one for sharing, and one for embedding.

The share link contains the current viewpoint for your scene, so you can send the 3D model in your chosen position to your clients and partners.

If you wish to include the 3D model inside your webpage, you only need to copy the embed code and paste it into the source code of your website or blog.

# 3MX Web Deployment

The ContextCapture Web Viewer Interface



## 3MX Web Deployment

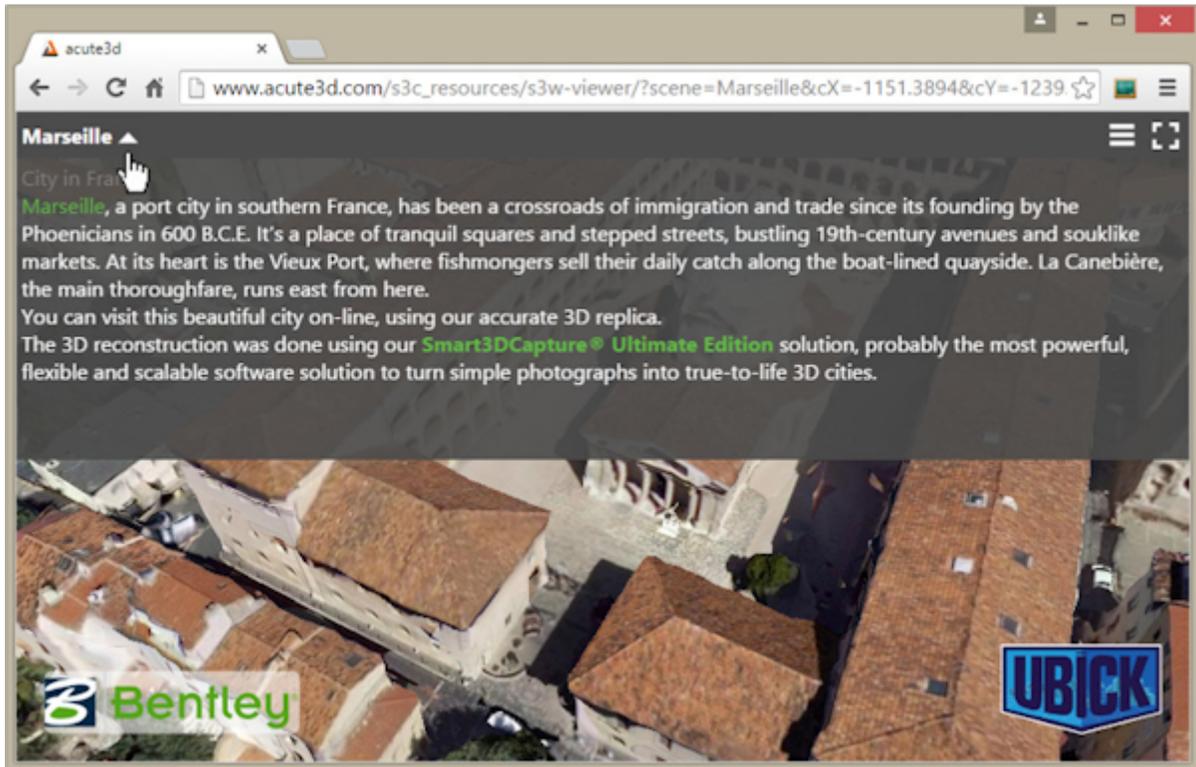
Appendix A: View the ContextCapture Web application locally

---

### More information

You can find extra information about the navigation in the Help window, accessed via Menu → Help.

The information about the 3D scene is found by clicking on the model title, in the upper left corner.

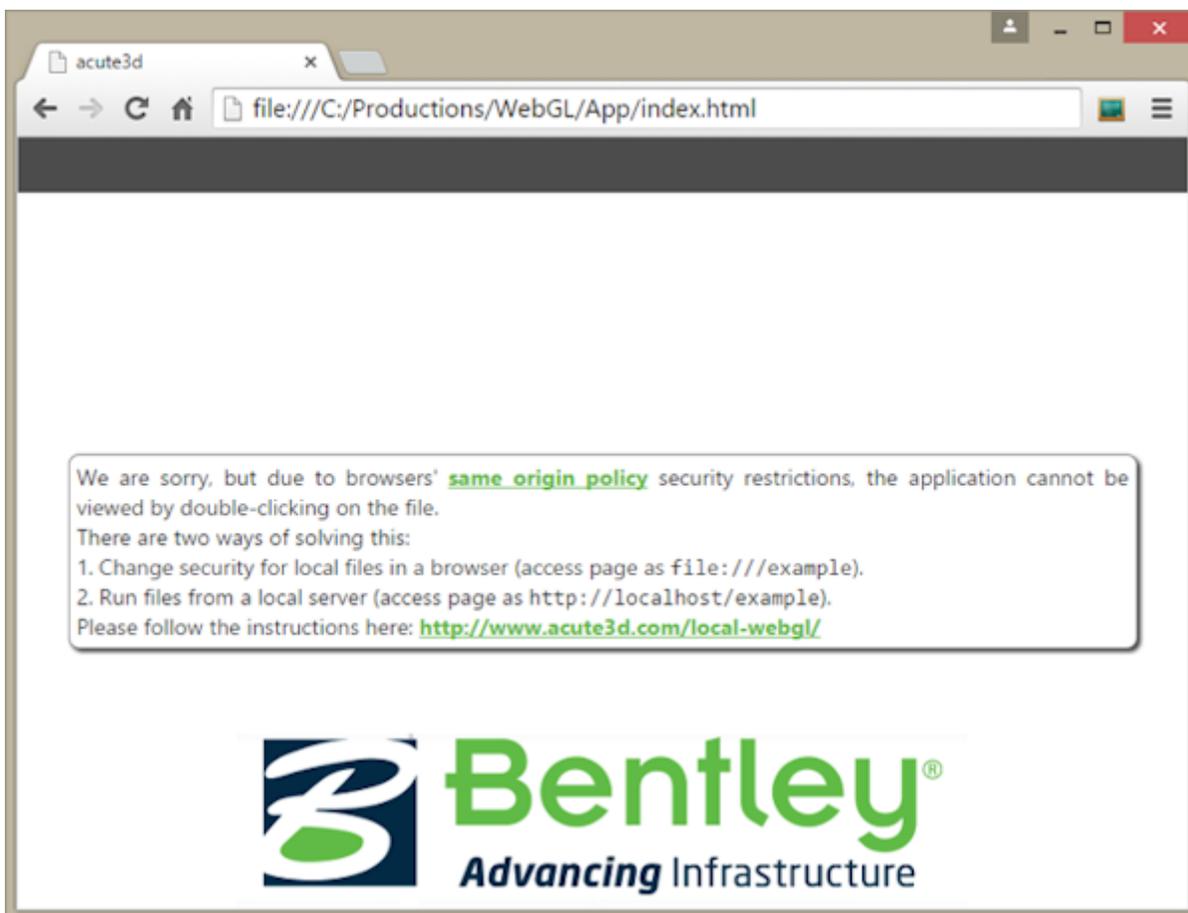


### Appendix A: View the ContextCapture Web application locally

Due to browsers' [same origin policy](#) security restrictions, loading from a file system will fail with a security exception, as in the screen capture below.

## 3MX Web Deployment

Appendix A: View the ContextCapture Web application locally



There are two ways of solving this:

- Change security for local files in a browser (access page as file:///example)
- Run files from a local server (access page as http://localhost/example)

If you use option 1, be aware that you may open yourself to some vulnerabilities if using the same browser for a regular web surfing. You may want to create a separate browser profile / shortcut used just for local development to be safe. Because of these security issues, we strongly recommend you to use option 2.

If you plan on regularly producing scenes for web viewing, using option 2 will not only be the secure way of visualizing the data, but it will also be less time consuming. The local server setup only needs to be done once, and then it will be ready for use every time you wish to view a new production.

### Change local files security policy

Firefox:

- Go to about:config (type the address in the Firefox navigation bar)
- Find security.fileuri.strict\_origin\_policy parameter
- Set it to false

## 3MX Web Deployment

### Appendix A: View the ContextCapture Web application locally

---

#### Chrome:

- Close all running Chrome instances first. The important word here is 'all'. On Windows, you may check for Chrome instances using the Windows Task Manager. Alternatively, if you see a Chrome icon in the system tray, then you may open its context menu and click 'Exit'. This should close all Chrome instances.
- Start a command prompt / terminal. On Windows, type Command Prompt in the Search box, and then, in the list of results, double-click Command Prompt.
- Find the Chrome executable folder. On Windows, search for the file chrome.exe in a Navigator windows.
- In the command prompt terminal, start the Chrome executable with a command line flag: `path_to_chrome/chrome --allow-file-access-from-files`

#### Internet Explorer

Theoretically, Internet Explorer allows changes in the local files security policy. However, in our tests the options had no effect under Windows 8.0.

#### Safari

- Enable the develop menu using the preferences panel, under Advanced → "Show develop menu in menu bar".
- Then from the Safari "Develop" menu, select "Disable local file restrictions".
- If you are editing & debugging using Safari, it is advisable to also select the "Disable caches" option in the same menu.

#### Run local server

There are several options to choose from when installing a local server, for example [Apache](#), [Wamp](#), or [nginx](#). We are only going to suggest one, which has the advantage of being a zero-configuration server: [http-server](#).

#### Installation

- Install Node.js by using one of the installers from <https://nodejs.org/>.
- Start a command prompt / terminal. On Windows, type Command Prompt in the Search box, and then, in the list of results, double-click Command Prompt.
- Make sure the last version of npm is installed by running this command in the terminal: `sudo npm install npm -g`. In Windows, you can drop the sudo keyword, but you should run the command prompt as administrator.
- Run in command prompt / terminal: `npm install http-server -g`
- Create a folder where you wish to store all your server data, including the 3MX data.

#### Use

- Place your 3MX data and your web viewer copy inside your server folder (the folder you created in the Installation phase)
- Start a command prompt / terminal. On Windows, type Command Prompt in the Search box, and then, in the list of results, double-click Command Prompt
- In the terminal, go to your server folder
- Type `http-server`

## 3MX Web Deployment

Appendix A: View the ContextCapture Web application locally

---

- You can now access the server in any browser by typing `http://localhost:8080`. Navigate to the web viewer folder to visualize your productions. You can check the “[Configuring the web viewer](#) (on page 237)” section to see how to use the same web viewer for all your scenes.

# 3D multiresolution Mesh eXchange format (3MX)

---

## 3D multiresolution Mesh eXchange format (3MX) Introduction

This document specifies the 3D multiresolution Mesh eXchange format (3MX). In designing 3MX, the goal was to create a lightweight open format that facilitates the distribution of our ContextCapture data, both online and toward 3<sup>rd</sup> party applications.

The intended usage of 3MX is:

- Online distribution, by using our new WebGL viewer.
- Interoperability with other Bentley Systems products, such as MicroStation.
- Interoperability with 3<sup>rd</sup> party applications (3D GIS).

3MX relies on a multi-resolution approach to achieve fast retrieval of very large 3D mesh data. Together with the mesh compression used by the format, this makes data streaming possible for 3D rendering. Presently, both ContextCapture native viewer and our new WebGL viewer are able to read 3MX, locally or from a server.

The 3MX format was conceived with extensibility in mind. ContextCapture currently produces 3MX data using a single mesh compression type (OpenCTM), and a unique type of texture (JPG). However, the 3MX specification puts no limits on the representation types for either meshes or images.

All this said, the main characteristics of 3MX are:

- Web friendly: easy to load in browsers
- Compactness
- Optimized for streaming: fast display possible.
- Extensible
- Multi-resolution representation: for handling very heavy data.

The multi-resolution approach used in 3MX relies on a set of principles, described in the next section.

## Level of detail principles

The Level of detail (LOD) format allows the loading and visualization of very large 3D models. It does so by:

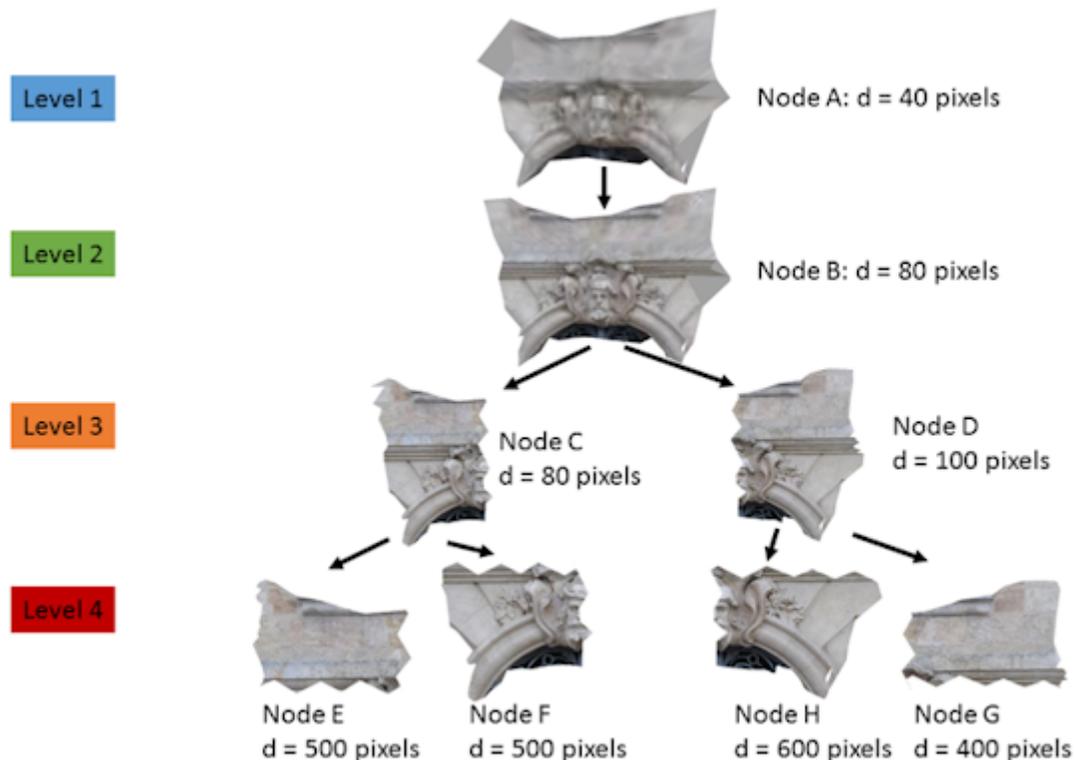
- Decreasing the complexity of the representation as it moves away from the viewer.
- Only loading the parts of the model that are visible from the current point of view.

The LOD uses a tree structure, where the topmost node is a very coarse geometry, and the children are of a progressively finer geometry. The leaf nodes are the finest granularity of the 3D representation.

## 3D multiresolution Mesh eXchange format (3MX)

### Level of detail principles

Below is an example of a LOD tree, where each node contains geometry and texture. Different from a point cloud LOD representation, the child contains a full mesh specification that completely replaces the parent mesh.



The Level 2 node, for example, is split into 2 children, each containing half of the model, but at a finer scale than the parent. When showing Level 3 nodes, Level 2 should be hidden.

The nodes are shown according to their proximity to the screen. Reverting to our example, when we are far away from the screen, node A (Level 1) is shown. As we get closer and closer, the nodes are replaced by their children. Node B will replace node A, for example, and nodes C and D will replace node B. If we zoom on the node C, it might be that node C will be replaced by level 4 nodes E and F, while its sibling, node D, remains unchanged.

In the process of replacing nodes by their children, it might be the case that the node needs to disappear, without any geometry replacing it. Or mesh simplification can reduce so much a node geometry that the parent holds no triangle. Both situations require an empty node. Empty nodes are sometimes possible in our LOD representation, and they should be considered.

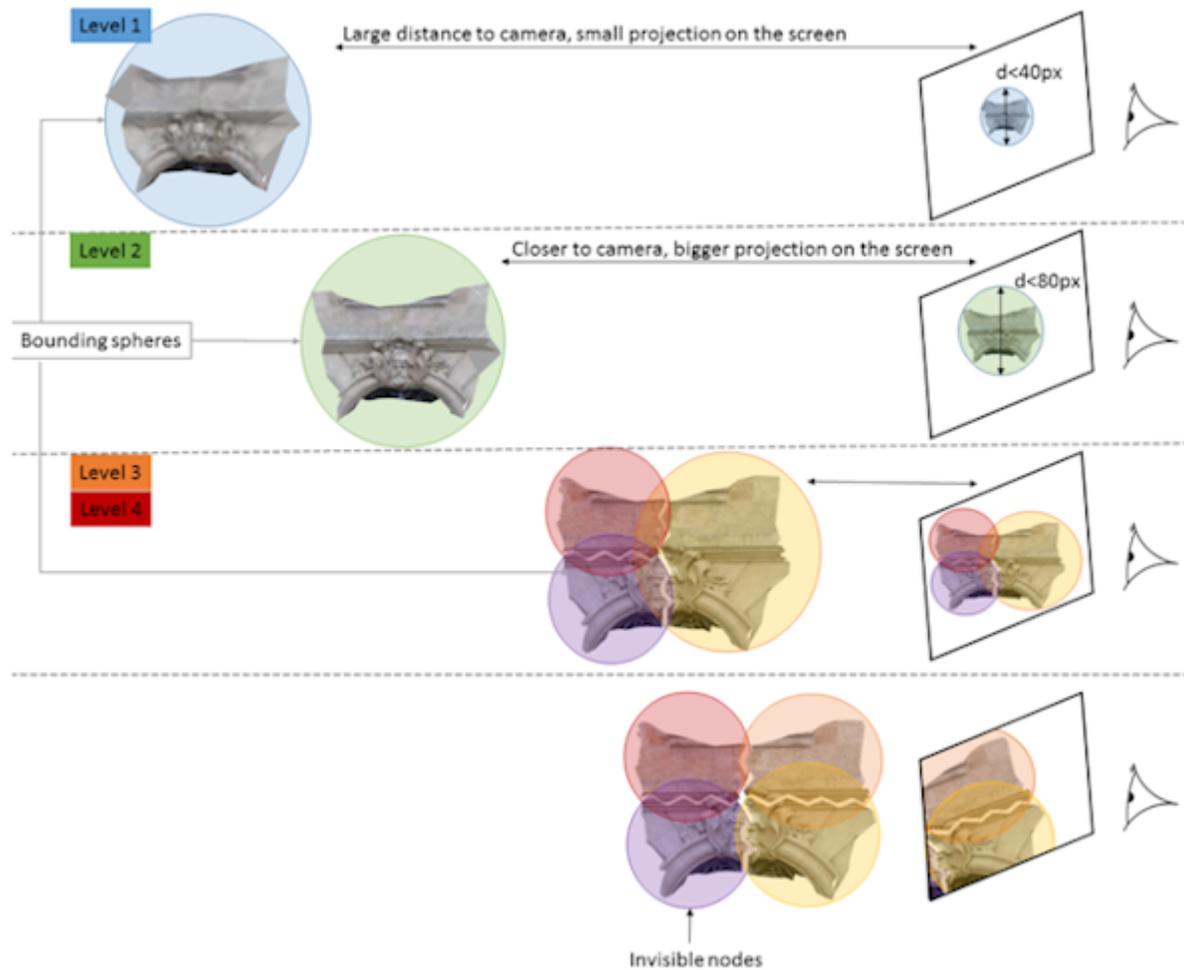
At any given time, only one node from a possible tree path is shown. In our LOD example, if the node B is shown, then the Level 1 node is not shown, and neither are any of node B's descendants.

The question now is, when is a certain node "close enough" to be shown on the screen? For this, the ContextCapture (Viewer or Web Viewer) approach is to consider how big the node appears on the screen (in pixels). To speed up calculations, the node's bounding sphere is used as a proxy. The projection of the bounding sphere on the screen is a circle of diameter  $d$ . The diameter  $d$  is used as the measure of how big the node is on the screen.

Each node has attached a pixel maximum screen diameter. This value represents the maximum value of the projected bounding sphere diameter  $d$  for which the node should be visible. Once this value is surpassed, the node should be replaced by its children.

## 3D multiresolution Mesh eXchange format (3MX)

### Level of detail principles



In the example above, node A is shown for as long as its bounding sphere is projected onto the screen as a circle of a diameter less than 40 pixels. When the bounding sphere projection becomes too large, node B is loaded and shown.

As we get closer to the model, we advance in the tree structure towards higher resolution nodes, but only for visible areas! This means that only a small portion of the tree will be loaded in the memory at high resolution.

In our example, nodes E and F become invisible when the camera zooms in on node D. So, while the D part of the model is needed at a high resolution, nodes C, E and F are not useful anymore. To minimize memory consumption, they should be deleted.

In general, a node is deleted when it has been invisible for a certain period of time. The nodes are not deleted immediately after becoming invisible, because they have a high likelihood of becoming visible again when the camera moves slightly. The delay in deleting the nodes ensures that the nodes are unlikely to be needed soon. Nodes are not deleted if any of the children are still needed.

To resume, the principal ideas in LOD visualization of ContextCapture (Viewer or Web Viewer) data are:

- Only one node from a path from root to leaf is seen at any given time.
- A node is seen when its projection on the screen is within a predefined range (in pixels).
- A node is loaded only when needed (when the parent is reaching the maximum projection area on screen).

## 3D multiresolution Mesh eXchange format (3MX)

### 3MX format

- Nodes that are unseen for a certain period of time are deleted.

## 3MX format

The 3MX format consists of 2 types of file: one master file in JSON format and a tree of sub-folder/sub-files in binary format. The single master file contains the scene metadata, and it is identified by the 3MX extension. The binary files contain the geometry, and are of type 3MXB (3MX binary). The 3MXB files typically describe one unique 3D textured pyramidal mesh.

Figure 3 shows an example of folder organization for a 3MX scene. The scene file is found in the root folder. The mesh description is split in multiple files, organized in a tree structure. Sub-folders represent subtrees of some intermediary node in the LOD structure described in the previous section.



Figure 120: Example of 3MX scene folder organization

## 3MX file

The 3MX contains general information about the scene, in JSON format. The JSON format was chosen because it is easy to handle and parse by web clients.

A file in 3MX format holds:

# 3D multiresolution Mesh eXchange format (3MX)

## 3MX format

- 3mxVersion – The file’s version number (float number)
- name – The scene name (utf-8 string)
- description – A description of the scene (utf-8 string).
- It can contain HTML tags, but it should not contain new lines.
- logo – Logo of the owner of the scene, as a relative path to an image (JPG or PNG).
- sceneOptions – A collection of display options for the scene.
- layers – One or several layers, containing different types of data. The geometry present in a scene is described in such layers.

The sceneOptions tag is reserved for the displaying application; custom fields can be added to define application-related options.

In the layers collection, each layer has to have an ID and a type. Type-dependent data can be added to a layer description.

Figure 4 shows a schema of the 3MX organization.

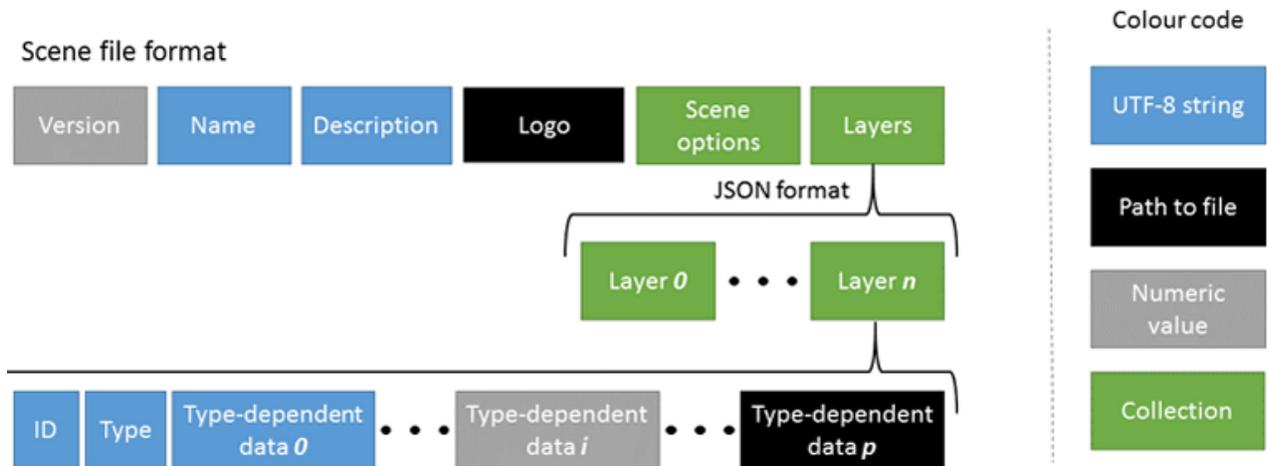


Figure 121: 3MX scene file format

For now, 3MX declares a single type of layer: meshPyramid. The meshPyramid layer describes a unique 3D textured pyramidal mesh, in the 3MXB form.

## 3D multiresolution Mesh eXchange format (3MX)

3MX format

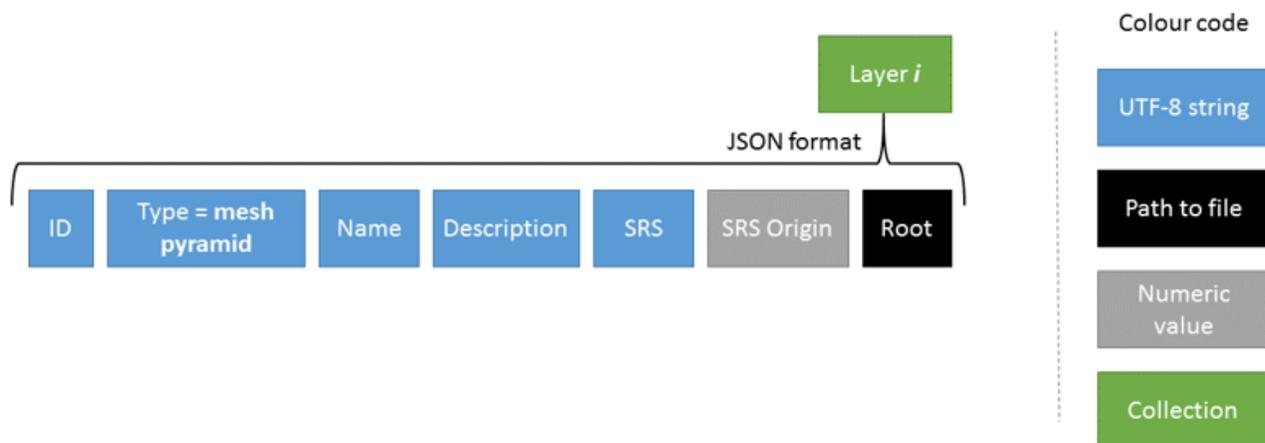


Figure 122: Mesh pyramid layer

A layer of type meshPyramid contains the following set of tags:

id		The layer's ID (utf-8 string).
type:	meshPyramid	The layer type.
name		The layer name (utf-8 string).
description		A description of the layer (utf-8 string).
SRS		The spatial reference system (utf-8 string). Only needed for georeferenced data. See also About Spatial reference systems.
SRSOrigin:	[O <sub>0</sub> , O <sub>1</sub> , O <sub>2</sub> ]	The model origin, in the specified SRS (array of float32). A point's correct coordinates in the specified SRS are $P = P_{\text{mesh}} + \text{SRSOrigin}$ . Optional.
root		The relative path to the root 3MXB file (utf-8 string).

As an example, here is a full 3MX scene file:

```
{
  "3mxVersion": 1,
  "name": "Marseille",
  "description": "Marseille was generated using InterAtlas' oblique imagery system. ",
  "logo": "interatlas_logo.png",
  "sceneOptions": [{"navigation_mode": "PAN"}],
  "layers":
  [
    {
```

## 3D multiresolution Mesh eXchange format (3MX)

3MX format

```

"type": "meshPyramid",
"id": "mesh0",
"name": "Marseille",
"description": "This is a description of the model. It should be between quotation
marks.",
"SRS": "EPSG:32631",
"SRSOrigin": [692625,4798280,0],
"root": "Data/Marseille.3mxb"
  }
]
}

```

Using the root contained in the scene layers, the geometry can be loaded, starting with the root 3MXB file.

### 3MXB file

3MXB geometry format respects the LOD principles described in the first section. It is organized as a tree structure, where children are a higher-resolution representation of the parent node.

A 3MXB file is written in binary format. It packs or references all the data needed by a node or by a set of nodes, including all the textures and all the geometry. A single 3MXB file can represent several nodes in the LOD tree; in this case, all the nodes are siblings, children of the same lower-resolution node.

The 3MXB format has the following structure:

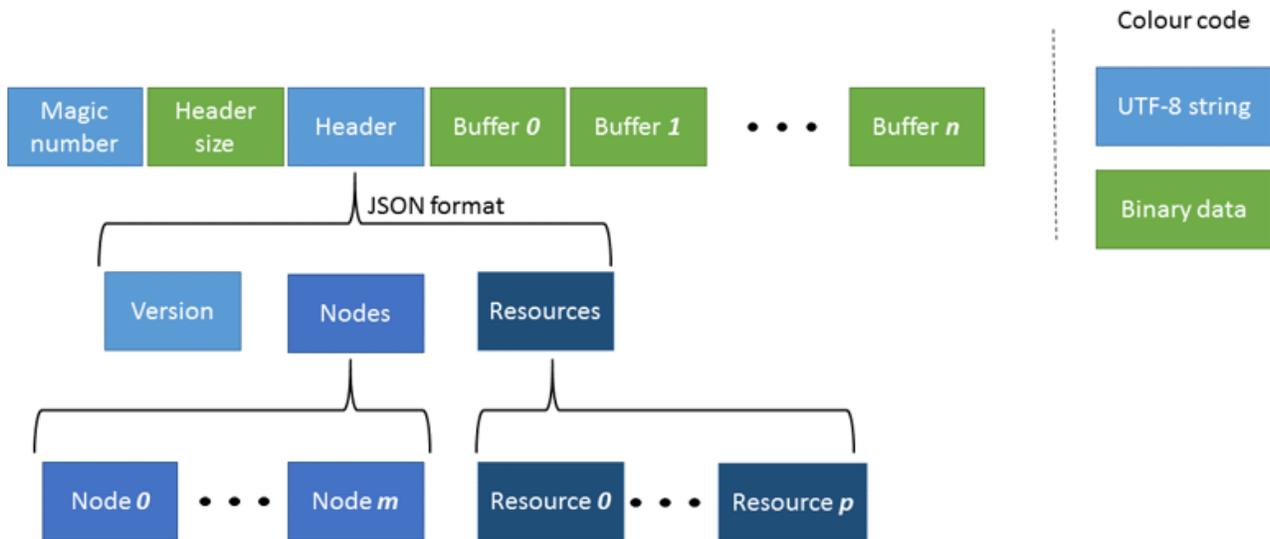


Figure 123: 3MXB file format

A 3MXB file starts with the magic number “3MXB0”. Following it is SH – the size of the file’s header in bytes; SH is a number in binary format (uint 32).

The file header comes immediately after SH. The header is a string of size SH, in JSON format, made up of:

version:	1	
----------	---	--

## 3D multiresolution Mesh eXchange format (3MX)

3MX format

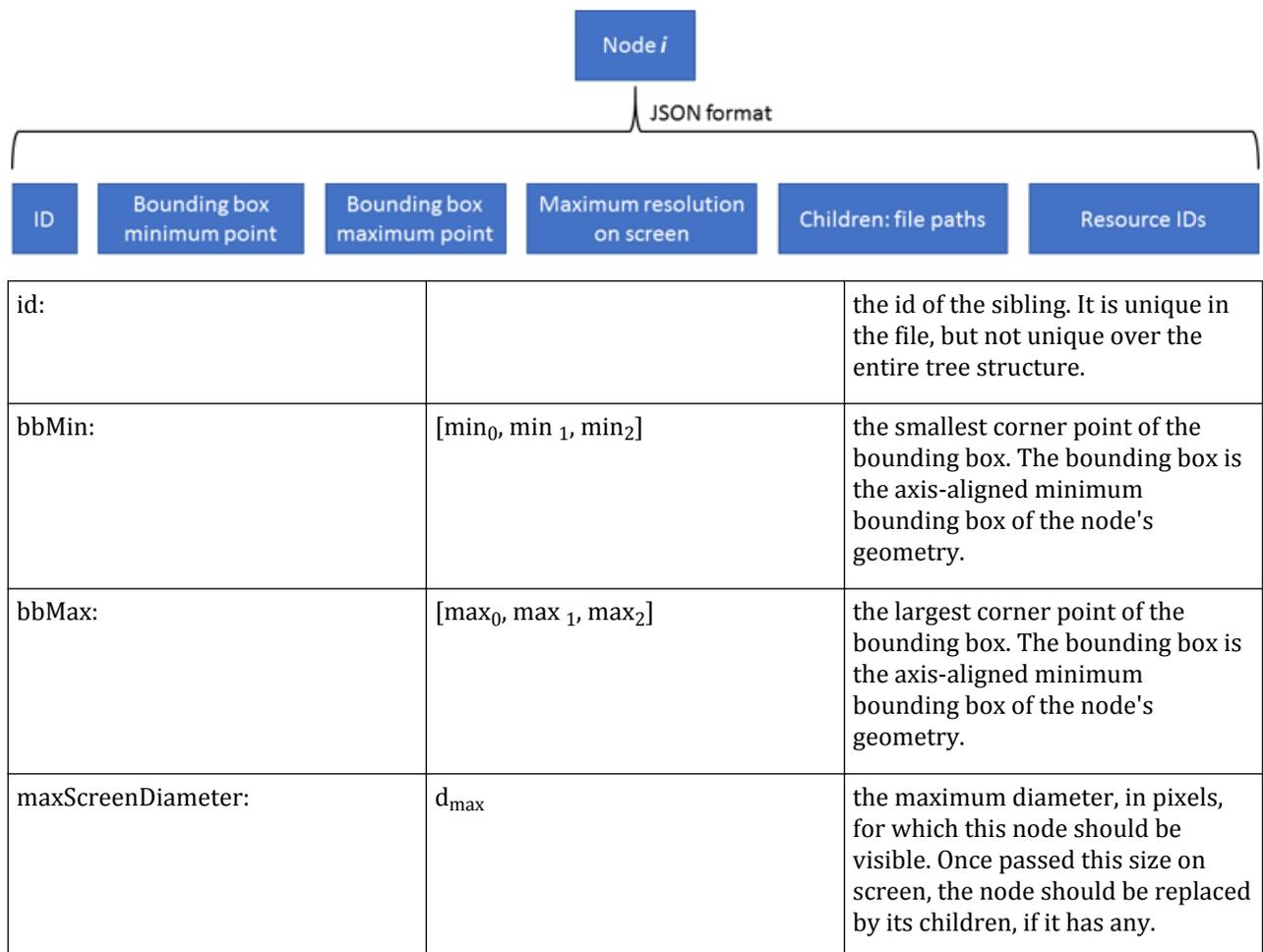
nodes:	[node_data <sub>0</sub> , ..., node_data <sub>m</sub> ]	array of sibling data, one for each sibling. The content of the node data will be specified in a dedicated section.
resources:	[resource_data <sub>0</sub> , ..., resource_data <sub>p</sub> ]	array of resource metadata, one for each resource (texture or geometry) needed by the nodes. The resource data is detailed further below.

The 3MXB file finishes with a number of binary buffers:

Buffer <sub>0</sub> :	a binary data buffer. The buffer type and its other properties are specified in the header's resources.
Buffer <sub>n</sub> :	a binary data buffer.

### Node data

The node data contained in the header holds all the metadata for a single node included in the file:



## 3D multiresolution Mesh eXchange format (3MX)

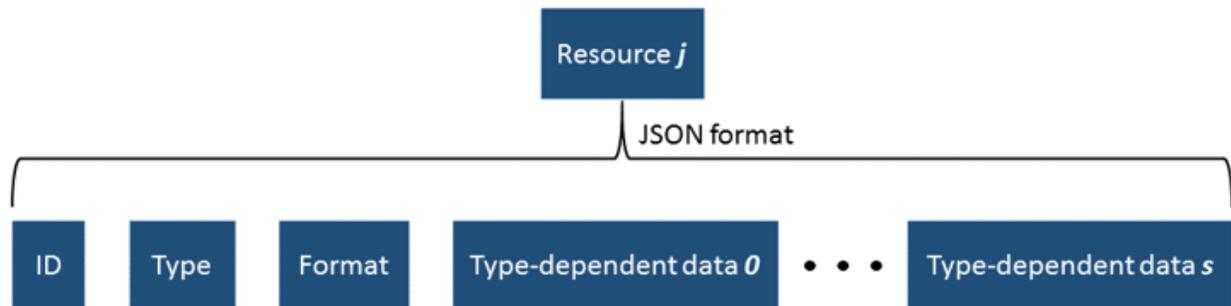
### 3MX format

children:	[file_name <sub>0</sub> , ...,file_name <sub>p</sub> ]	list of files (relative path) that contain the node's children.
resources:	[geometry_ID <sub>0</sub> , ...,geometry_ID <sub>r</sub> ]	list of the geometries forming the node. The ID points to a resource in the header's resources collection.

Note that the node's resources array can be empty, defining in effect an empty node. Empty nodes are sometimes possible in the 3MX format, and they should be considered. They indicate that the parent geometry has to be made invisible, without it being replaced by another geometry. The absence of children indicates, on the contrary, that the node remains visible always, even if its screen projection surpasses its maxScreenDiameter parameter.

### Resource data

The header's resources collection describes all the resources needed to complete the definition of the entire set of nodes contained by the 3MXB file. For each resource, the data is organized as follows:



The resource ID is used to link nodes and resources together. For example, the ID is used to attach the geometry to the correct node, and to link the geometry to the corresponding texture.

Four types of resources are possible:

- textureBuffer, where the texture is included in the 3MXB file.
- geometryBuffer, that describes a mesh as a binary buffer in the 3MXB file.
- textureFile, where the texture is an external file.
- geometryFile, where the mesh is an external file.

For the buffer types, the binary data is included after the header, in one of the buffer objects. The buffers appear in the same relative order in the resource collection and in the buffer collection.

#### 1. textureBuffer

The texture buffer JSON data is organized as follows:

```
{
  "type": "textureBuffer",
  "id": "tex0",
  "format": "jpg",
  "size": 1513,
}
```

## 3D multiresolution Mesh eXchange format (3MX)

### 3MX format

---

The "id" identifies the texture in a unique way in the file, but the id is not unique over the entire tree structure.

The "format" tag indicates the type of the texture image. The image in a texture buffer is saved as a binary buffer in the 3MXB file. The size of the binary data is indicated by the "size" value.

#### 2. geometryBuffer

The geometry buffer metadata is:

```
{
  "type": "geometryBuffer",
  "id": "geometry1",
  "format": "ctm",
  "size": 835,
  "bbMin": [-1243.69, -314.572, 52.6138],
  "bbMax": [1243.69, 314.572, 52.6138],
  "texture": "tex0"
}
```

The "id" identifies the geometry in a unique way in the file, but the id is not unique over the entire tree structure.

The "texture" tag is optional, and it appears only if the geometry has a texture. In this case, the texture is identified by its ID. In the example above, the geometry uses the "tex0" texture defined in the "Texture buffer" section.

The "bbMin" and "bbMax" values describe the geometry's bounding box, in the same way as in the node data.

#### 3. textureFile

The texture file JSON description is very similar to the texture buffer, except that instead of the size of a buffer, it indicates the path to an external file containing the image.

```
{
  "type": "textureFile",
  "format": "jpg",
  "id": "tex1",
  "file": "subfolder/SomeTexture.jpg",
}
```

#### 4. geometryFile

Like the texture file, the geometry file JSON contains the "file" tag, which points to an external geometry file.

```
{
  "type": "geometryFile",
  "format": "obj",
  "id": "geometry1",
  "file": "subfolder/SomeMesh.obj",
  "texture": "tex1"
}
```

## References by ID

The 3MXB file includes several resources, all of which have to be matched together. As mentioned before, the resource ID is used to link nodes and resources together.

The first correspondence is between the node and its geometry. The node data includes a resources array, enumerating the IDs of every geometry resource belonging to the node. The header's resource array lists all the

## 3D multiresolution Mesh eXchange format (3MX)

### 3MX format

resources needed by at least one node in the file. By matching the node's resource IDs with the header resource IDs, the node's geometry can be reconstructed.

In the image below, Node 0 has Resource 0 and Resource 1 as geometries. While Resource 0 is of type geometry file, Resource 1 is of type geometry buffer, and the mesh is packed in Buffer 0. Node 1 is defined by the Resource 2 geometry, found in Buffer 1. The order of resource appearance in the header is preserved for the buffers, so the attribution of Buffer 1 to Resource 2 is done automatically.

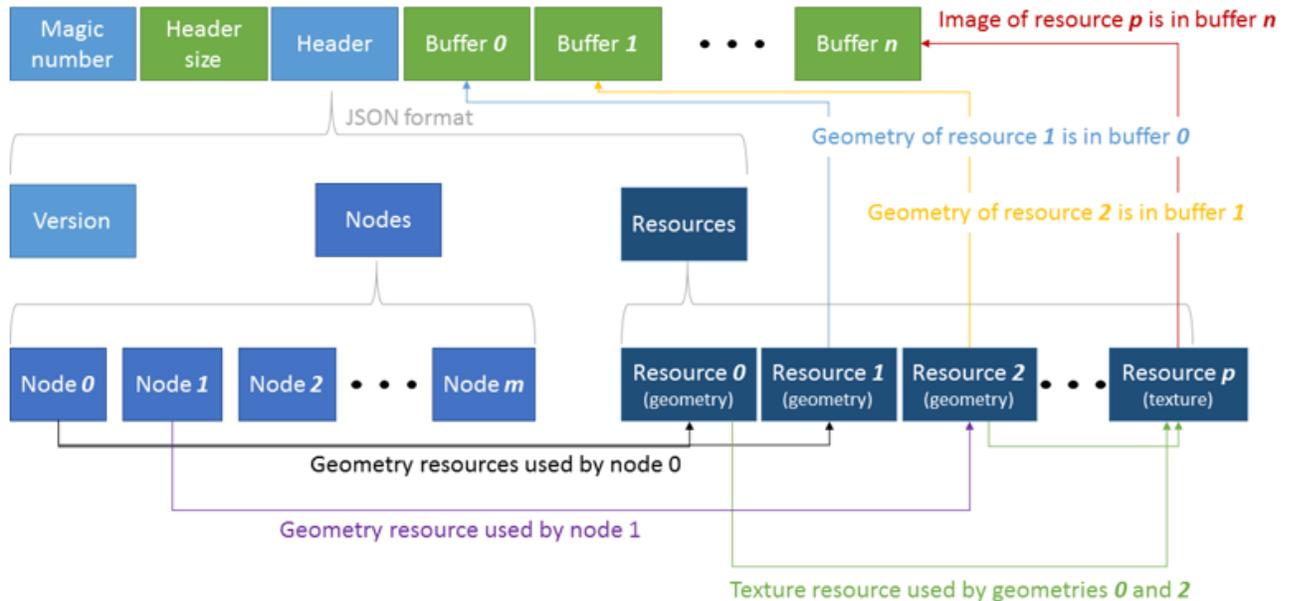


Figure 124: Resource attribution in 3MXB. The green color represents binary data, and the blue nuances represent string data.

A geometry belongs to a single node, but a node can have zero, one or several geometry meshes. The reasons for the node having more than one geometry are twofold. In the first place, a single node can have textured and untextured data or data textured with several images. In this case it is convenient to separate the geometry in several buffers, each corresponding to a single texture. In the second place, certain systems impose a geometry buffer of at most MAX\_USHORT length. For instance, when produced for the WebGL viewer, the geometry is split into buffers no larger than MAX\_USHORT (65,535). This can be adapted to the targeted viewer.

The second correspondence is between the geometry mesh and the corresponding texture. The resource ID is again used for the matching. A geometry mesh can have either a single texture or none at all. If a texture is needed, the "texture" tag is present in the geometry description. The indicated texture ID should be the ID of one of the texture resources listed in the header's resource collection.

A texture can be used in different nodes, and by several geometries. In our example above, Resource 0 and Resource 2 both share the texture in Resource p.

A header complete example, in JSON format:

```
{
  "version":1,
  "nodes":[
    {
      "id":"node0",
      "bbMin":[28.7803, -12.6859, 17.3977],
      "bbMax":[30.7065, -2.68368, 28.2069],
```

## 3D multiresolution Mesh eXchange format (3MX)

Current implementation

---

```
    "maxScreenDiameter":118.819,
    "children": [ "Tile_p000_p000_p001_L20_00.3mxb" ],
    "resources": [ "geometry0" ]
  }
],
"resources": [
  {
    "type": "textureBuffer",
    "format": "jpg",
    "id": "texture0",
    "size": 1665
  },
  {
    "type": "geometryBuffer",
    "format": "ctm",
    "id": "geometry0",
    "texture": "texture0",
    "bbMin": [28.7803, -12.6859, 17.3977],
    "bbMax": [30.7065, -2.68368, 28.2069],
    "size": 1233
  }
]
}
```

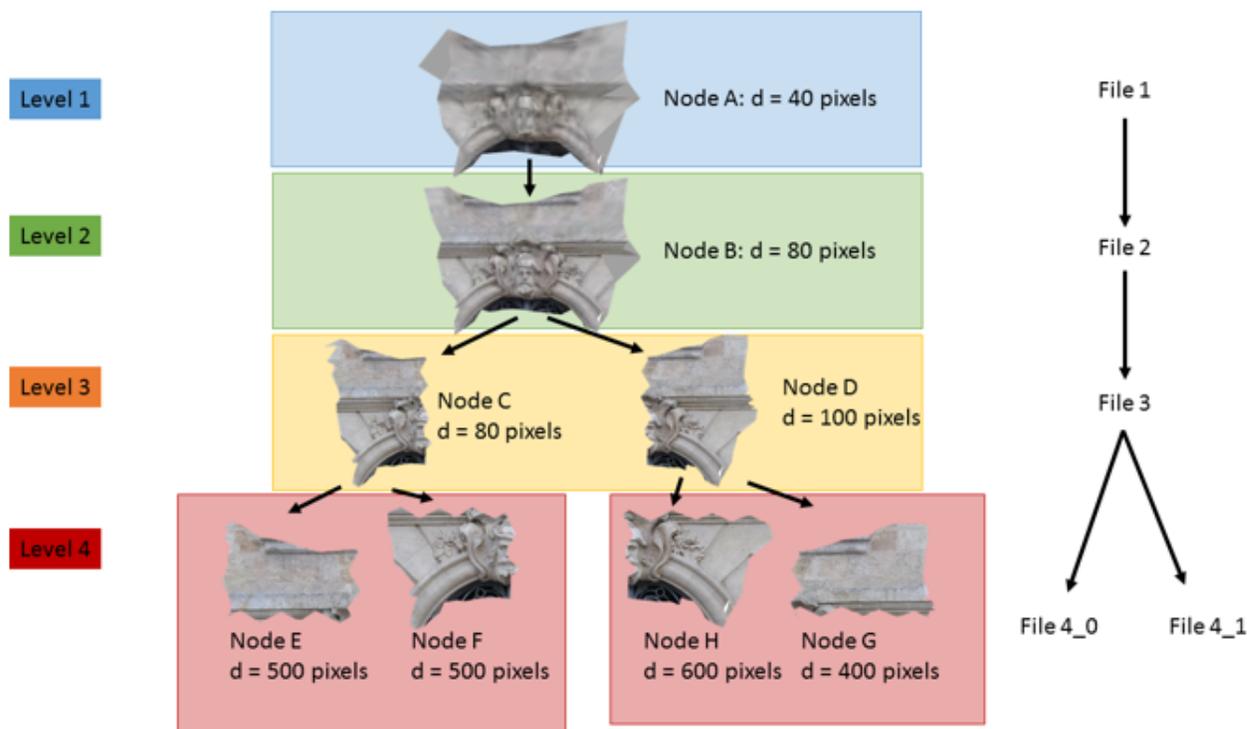
### Current implementation

Currently, ContextCapture exports the 3MX format with a number of fixed parameters, resulting in a particular version of the 3MX format.

One particularity of the ContextCapture export is that all the children of a node are stored in a single 3MXB file. This is done to speed-up loading, and to reduce the used memory. If we revert to our example from the Level of detail principles section, the exported 3MX scene will look like this:

# 3D multiresolution Mesh eXchange format (3MX)

Current implementation



where the square areas represent a 3MXB file.

## 3MX Export

The 3MX scene currently exported is limited to one unique 3D textured pyramidal mesh. This means that a single layer is generated, of type meshPyramid. Other data, such as OBJ meshes or labels attached to the 3D mesh, are not considered in the present implementation.

Aside from the single layer, the exported 3MX file has a single scene option in the sceneOptions collection. This option is navigationMode, and it can be either "ORBIT" or "PAN". This option can be used to initialize the way the user interacts with the scene.

## 3MXB export

The exported 3MXB files each contain a siblinghood in the LOD tree, packed in a single binary file. The produced 3MXB will therefore only have resources of type texture buffer and geometry buffer. Resources of type texture file or geometry file are not being generated by ContextCapture.

### 1. textureBuffer

Currently, only the jpg format is supported by the ContextCapture export. The jpg is packed inside a file buffer, without modifications.

### 2. 2geometryBuffer

A geometry buffer is currently only an OpenCTM file (<http://openctm.sourceforge.net/>), saved as a binary buffer in the 3MXB file.

## 3D multiresolution Mesh eXchange format (3MX)

About Spatial Reference System

---

The OpenCTM format includes:

positions $[v_0, \dots, v_n]$	array of vertex positions. $v_i = [p_0, p_1, p_2]$
normals $[n_0, \dots, n_n]$	array of vertex normal. Optional, and currently not included.
texture coordinates: $[uv_0, \dots, uv_n]$	array of vertex texture coordinates. $uv_i = [u, v]$ . Only valid when the geometry has an attached texture.
triangle indices: $[i_0, \dots, i_t]$	array of vertex indices, $i_x =$ an array position in the vertex array. The indices, takes by 3, form the triangles.

## About Spatial Reference System

The spatial reference system is defined with a single definition string, which is commonly an EPSG definition, or a Well Known Text (WKT) string. Some specific custom definitions may also be used.

EPSG codes

Most EPSG definitions corresponding to standard projection cartographic systems are supported.

The syntax is "EPSG:CODE" to define a cartographic system with its EPSG code (for instance "EPSG:32651").

Non metric systems are not used (eg. geographic systems).

Well Known Text (WKT)

OpenGIS Well Known Text format for coordinate systems can be provided in as is.

Other definitions

The following syntax may be used to define local East-North-Up (ENU) systems: "ENU:LAT,LON" (for instance "ENU:41.57231,2.26157").

## Pointclouds Technical Specifications

### PTX

#### General

ContextCapture supports PTX format from Leica Cyclone.

All PTX point clouds are considered to have intensity information and so point clouds will always have the intensity attribute. Color information is detected if a point line has seven elements.

#### Static

Header length and point list lengths must be reliable. A missing line in the header or a missing point between two headers leads to a failed importation. However, a corrupted point line will be ignored.

## 3D multiresolution Mesh eXchange format (3MX)

Point coordinates is computed using scanner registered position as scanner location and the transformation matrix.

If the scanner position is provided from the user interface, the transformation matrix in the PTX header is still used to compute point coordinates. Autodetect position feature is not available for PTX.

### LAS

#### General

ContextCapture supports LAS format 1.0, 1.1 and 1.2.

Color information is detected based on LAS Point data record format used. Point clouds will have a color attribute if the point format used is 2 or 3. Intensity attribute is detected if at least one point doesn't have an intensity set to 0.

#### Static

LAS format doesn't support scanner position information. When importing a static LAS, the user must provide a scanner location from the user interface or use the autodetect feature.

#### Mobile

The point clouds and the trajectory data are linked using timestamps. Therefore, LAS point data record format must be 1 or 3.

### E57

#### General

ContextCapture support E57 format 1.0 and Leica E57 timebounds.

Color information is detected based on the E57 file header. If in the header, the point fields of blue color, red color and green color are set to true, the pointcloud will have color attribute. For intensity, the point field of intensity is used to set the intensity attribute.

#### Static

The position of scanners is read from the pose information of each E57 scans. If this information is missing, ContextCapture assumes the pose is set to the identity. Georeferenced static scans must have a pose information, as an identity pose doesn't make sense for georeferenced point clouds.

If the scanner position is provided from the user interface or is autodetected, the pose information in the E57 scans is still used to compute point coordinates.

#### Mobile

The point clouds and the trajectory data are linked using timestamps. Therefore, at least one E57 scan must have a timestamp field. If the E57 scan as an acquisitionStart structure, the value is used as an offset for the timestamp stored for each point. If the E57 has a timeBounds structure and a timeMinimum structure, the timeMinimum value is used as an offset for the timestamp stored for each point, overriding the acquisitionStart structure.

#### Trajectory data

Trajectory information is required to import mobile scans. A trajectory file must contain a list of the scanner positions associated with timestamps. The positions must be provided in the same spatial reference system than the point cloud coordinates, and trajectory timestamps must overlap with points timestamps.

Trajectory example:

```
Time;X;Y;Z  
189321.10;15.96;-52.12;133.68
```

## 3D multiresolution Mesh eXchange format (3MX)

Pointclouds Technical Specifications

---

```
189321.20;15.21;-51.21;134.01  
189321.30;14.75;-50.37;134.35  
189321.40;14.10;-49.50;134.31  
189321.10;13.78;-48.69;134.43  
...
```

### **PLY**

#### **General**

ContextCapture supports general PLY format and NavVis PLY format.

In ContextCapture, PLY format is considered a mobile format. No trajectory data is needed, but a normal information is required for each point.

Property names for normal must be nx, ny, nz. Property names for color must be red, green, blue.

#### **POD General**

ContextCapture supports POD format, the Bentley pointcloud format. Currently it is only possible to import it for static scans with a unique source.

#### **Static**

The user must specify the location of the scan for a specific POD file, or use the autodetect feature in order for the import to be successful.

## Numerics

- 2D/3D GIS software 29
- 3D multiresolution Mesh
  - eXchange format 257
- 3D view 72
- 3D Visualization 29
- 3MX Export 269
- 3MX file 260
- 3MX format 260
- 3MX Web Deployment 229
- 3MXB export 269
- 3MXB file 263

## A

- About paths with non-ASCII
  - characters 26
- About Remote desktop
  - connection 26
- About Spatial Reference System
  - 270
- About this document 217, 221
- About Windows session 26
- Add the scene description 235
- Add the scene image 235
- Add your logo 235
- Adding Photos 48
- Adding the camera model of a
  - photogroup 133
- Adding user tie points 65
- Additional data 86, 87
- Address bar parameters
  - 238–240
- aerotriangulation
  - Result display 96
- Aerotriangulation
  - Aerotriangulation report 97
- Aerotriangulation processing 95
- aerotriangulation result
  - Troubleshooting 99
- Aerotriangulation result 96

## Appendix A

- View the ContextCapture
  - Web application
    - locally 253
- Applications 99
- Apply a camera model from the
  - database 130
- Apply a camera model manually
  - to a photogroup 130
- Architecture 23
- ATExport XML format 128
- Automatic tie points checking
  - 99
- Axis constraint 67

## B

- Basemap manager 38
- Bing maps tile system 139–141
- Block 45
- BlocksExchange XML format
  - 119

## C

- CAD/3D software 28
- Camera database 129
  - capturing 22
- Change local files security policy
  - 254, 255
- Color equalization mode 146
- Command-line syntax and
  - allowed options 222
- Compatibility with older
  - versions of
    - ContextCapture 224
- Components 89
- Configuration 11
- Configuration file parameters
  - 240
- Configuring the 3MX 235
- Configuring the web viewer 237

## ContextCapture 21

- ContextCapture camera model
  - 217
- ContextCapture Engine 198, 199
- ContextCapture Master 30
- ContextCapture MasterKernel
  - SDK 214
- ContextCapture S3C Composer
  - 205
- ContextCapture Viewer 200,
  - 201
- ContextCapture Web Viewer
  - 202
- Control Point Properties 62–64
- Control points 59
- Control points checking 99
- Creating a new block by
  - aerotriangulation 88
- Creating a new production 159
- Current implementation 268

## D

- Delete color equalization 156
- deploy on the internet 242
- Description of the output
  - quadtree structure 224
- Description of the source tiling
  - structure 224

## E

- Example usage 222
- Export block 114
- Export instant loading scene file
  - 208
- Export to XML 114
- ExportUniqueMesh 221
- Extract block 112, 113

## F

Fields 107  
Fisheye camera model 219  
Formats 225

## G

General Block tab 47, 48  
General Reconstruction Tab 136  
Geometric simplification 145

## H

How to configure the web application and scene 234  
How to deploy the production 241  
How to produce for web viewing 229  
how to view locally 241

## I

Import blocks 108  
import photo positions  
    Data properties 104, 106, 107  
    File format 103  
    Input file 102  
Import photo positions 102  
Import retouches 149  
Import video frames 100  
Importing control points 61  
Input data file formats 19  
Input tile list 224  
Installation 10  
Inter-tile color equalization 155  
interoperability 29  
Interoperability 28  
Introduction 257

## J

Job Monitoring 215  
Job Queue Monitor 179

## L

Legacy format 227  
Level of detail principles 257  
Licensing 12, 225  
Link to the model 251  
Load/unload blocks 117, 118

## M

Manage the user camera database 132, 133  
mapping 22  
Measurements and GIS positioning 248  
Merge blocks 118  
More information 253  
Motivation 221  
MS Excel block definition 127

## N

natural environments 22  
Navigation 244–246  
New color equalization 155  
Node data 264

## O

Options 34, 35  
Origin constraint 67  
Output 225  
output block name 88  
output formats  
    3D mesh 161, 163  
    3D point cloud 164  
    Orthophoto/DSM 165, 166, 172  
Output formats 161

## P

Performance 26  
Perspective camera model 217  
Photo acquisition 17–19  
Photo properties 52  
Photogroups 49  
Photos 48  
Photos display options 69, 70

Plane constraint 68

Point clouds 54  
Positioning Constraints 66  
Positioning data 20  
Positioning/georeferencing 90–92  
Preparing the Imagery Dataset 17  
Principle 21  
Processing 225  
processing settings  
    Low-level settings 149  
Processing settings  
    Hole-filling 145  
processing settings tab  
    Geometric precision 145  
Production 158  
Production General 176, 177  
Production processing 161  
Project 31  
Project General 32, 33  
Properties 178  
Publish to Cesium 185  
Publish to Sketchfab 186  
Publish with ContextCapture Web Viewer 183

## Q

Quadtree structure 226  
Quality control 71, 72

## R

range subjects 22  
Reconstruction 134  
Reconstruction constraints 141  
Reference 3D model 142, 143  
Reference manager 35–38  
References by ID 266  
Region of interest 138  
Rendering 247  
Reset 154  
Resolution Limit 149  
Resource data 265  
Retouching 187, 188, 190  
Run local server 255

## S

- S3C Composer Main Interface 206–208
- Scale constraint 67
- Selection of matching pairs 144
- Set the default navigation mode 237
- Settings 92
- Software Editions 27
- spatial framework 137
- Spatial framework 137
- Spatial reference system 192
- Spatial reference system (SRS) 137
- Spatial reference system database 192, 194
- Split block 109
- Split processing 111
- Split settings 110, 111

Summary 221

System Requirements 25

## T

- The ContextCapture Web Viewer Interface 244
- The production options 230
- The production reference system 231
- The production result 232
- The web format 229
- Tie Points 64
- Tile selection 156–158
- Tiling 139–141

## U

- Untextured regions representation 148

urban environments 22

Use cloud services for hosting your production 243

Use your own server to host everything 242

Useful concepts 15

User defined system 195

## V

Vertical coordinate system 194

## W

Web publishing 29

Welcome 7

What's New? 7

Workflow 25