



Reality Modeling

ContextCapture[®]

Software to Automatically Generate Detailed 3D Models from Photographs







Quick Start Guide

Create 3D models from simple photographs



Who Should Read This Guide

New Users - This guide provides a reference for administrators and users who are installing and running **ContextCapture** for the first time.

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About This Guide

This guide provides important installation information to get gets you started with ContextCapture, including:

- System requirements
- Installation instructions
- About ContextCapture
- The acquisition basics





• Systematic simplified workflow

System Requirements

ContextCapture is a processing application that uses computer resources intensively.

These recommendations address the main PC components.

If you need to build more-complex architecture, contact Bentley support at +1 610 458 5000.

Hardware	Recommended
OS: Operating System	Windows 10 (64-bit) Windows 8 (64-bit) Windows 7 (64 bit) Windows Vista (64-bit) Windows XP (64-bit)
The fastest CPUs would be the Intel processors wi	th the most number of cores and the fastest speed possible
CPU: Central Processing Unit	Intel Core I7-4770 Intel Core I7-5820K Intel Core I7-6900K
Using gaming graphics cards is recommended. The NVidia GPUs are recommended.	ough ContextCapture can use Intel and AMD graphics cards,
GPU: Graphics Processing Unit	Nvidia GeForce GTX 1060 Nvidia GeForce GTX 1080 Nvidia TITAN X Pascal
A minimum of 32 GB of RAM is needed, but a 64 C	<i>GB</i> is required when processing several thousand photos.
RAM: Random-Access Memory	32GB of RAM 64GB of RAM 128+ GB of RAM (Requires Xeon processors. Only necessary when processing ultra-large blocks of photos.)
Hard Disk(s)	
When processing large projects, installing Con on a large HDD with fast read and write access WD6001FZWX) is recommended.	textCapture on a SSD drive with the project files stored s (for example, Western Digital HDD 6Tb
About the Network	
ContextCapture capabilities' work in a network machines. An efficient network that avoids both recommended.	environment to distribute tasks on different processing lenecks and ensures fast data transfer is





Installation Instructions

ContextCapture does not require administrator rights to operate. However, you must have administrator rights to install the application.

Once the installer is downloaded, double-click on the downloaded package cnctp040400351en.exe, and follow the installation instructions.

You are using an evaluation license of ContextCapture. Your license is 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: C:\Program Files\Bentley\ContextCapture Center \ eula.pdf.

The desktop displays three icons representing each of the three modules: 1. Acute3D Viewer, 2. ContextCapture Engine, and 3. ContextCapture Master.

Acute 3D			
Viewer			
ContextCap Engine			
ContextCap Master			

ContextCapture has a master module and an engine module.

The **master** module provides a graphical user interface to define input data, processing settings, submit processing tasks, monitor progress, and visualize results.

The **engine** module runs on a computer in the background, without user interaction, and performs the computationally intensive algorithms.

Remote Desktop Connection

ContextCapture Engine does not work through a Microsoft Remote Desktop Connection because in this type of environment hardware acceleration is disabled. However, you can use VNC or a remote administration software such as TeamViewer.

Windows Session

Switching the Windows User account while ContextCapture Engine is running will cause running computations to fail. In this scenario hardware acceleration is disabled when the user is not connected.

Regarding ContextCapture Dataset

Please download the **ContextCaptureDataset.zip** file and extract the datasets and data acquisition guide before continuing.

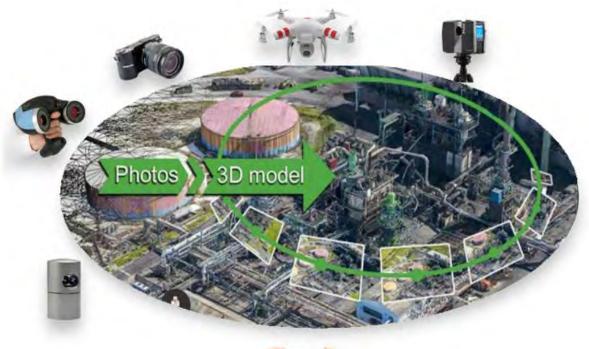




About ContextCapture

ContextCapture is developed by <u>Bentley Systems</u>, a leading global provider of comprehensive software solutions for *advancing* infrastructure.

ContextCapture allows you to automatically generate high-resolution 3D models from simple photographs or from point clouds, without any human intervention, with any digital camera, including a smartphone. Mount cameras on a drone or use a helicopter with a dedicated multi-directional acquisition system to capture aerial views of a city or structure.









ContextCapture Principle

1. ContextCapture takes as input a set of digital photographs of a static subject, taken from different viewpoints. It also imports frames from video files and point-cloud file formats.

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

3. 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.

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

Benefits: Modeling in a rich 3D environment that captures all details helps us to:



- Accelerate the design process (not starting from a blank canvas)
- Make better decisions (using detailed existing conditions as context)
- Use geographically located 3D models

Reality modeling technology using ContextCapture is fast, comprehensive, and accurate.

The Acquisition Basics





Great Models Require Good Data Capture

ContextCapture automatically converts photos into a 3D model, meaning that the quality of the input dataset has a deep impact on the output 3D model that is generated.

To get the best results using ContextCapture, we recommend:

- A constant focal length during the acquisition: zoom "with your feet"
- Ambient, constant, and homogeneous lighting

You should avoid:

- Blurry photos: use adapted settings, and possibly a tripod under low lighting conditions
- Flash light
- Optical stabilization

Never use:

- A digital zoom
- Any resizing/cropping/rotation of the input photos.

When capturing video, the following formats are recommended:

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

This section includes useful information on how to take photos to obtain optimal results with ContextCapture.

Capturing Tips - Basic Recommendations

- Use a suitable camera
- Shoot under natural light, cloudy weather (limit the shadows influence)
- Use a constant focal length during the acquisition

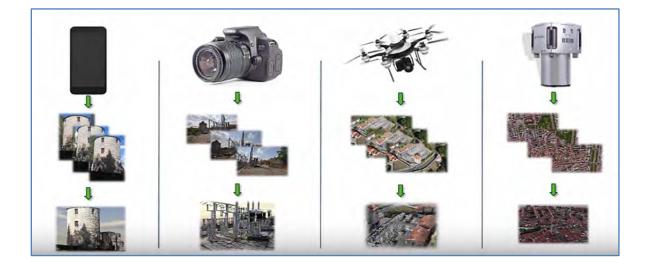
Camera models

ContextCapture supports a wide range of cameras: mobile phone, compact digital, DSLR, photogrammetric, and multi-camera systems. It can process still photographs or extracted video frames from digital video cameras. Any brand of camera/lens is recommended for ContextCapture, but the quality of the 3D model depends on the photo quality and geometric precision. For optimal results, use a camera with a large sensor, and a good-quality lens, such as a DSLR camera with a fixed lens.

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.



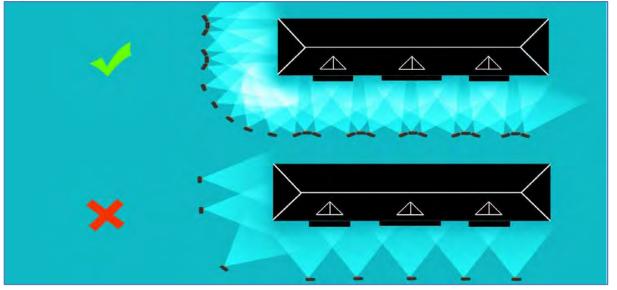




Overlap

Each part of the subject should be photographed from at least three distinct – but not radically different – viewpoints and should be less than 15 degrees apart. A minimum of 50 percent overlap is required, but a 70 percent overlap is recommended.

For aerial photography, a longitudinal overlap of 80 percent and lateral overlap of 50 percent or more are recommended. To achieve best results, acquire both vertical and oblique photographs. ContextCapture is remarkably robust for unstructured acquisition. You may, however, prepare a flight plan for more systematic acquisitions.



Note: Remember that the photo is at the basis of all the computation. With reasonable care and practice, you will generate amazing 3D models. The quality of the 3D reconstruction is dependent on the quality and the spatial sampling of your photos. Please refer to <u>Acquisition_Guide_V4_Bentley.pdf</u> for the Acquisition Techniques.





Systematic simplified Workflow

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

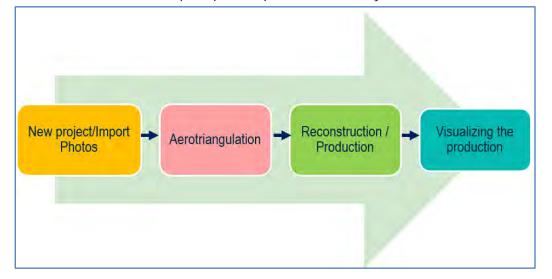
- a. Launch ContextCapture Engine
- b. Launch ContextCapture Master

Workflow 1: Using Photographs to create a 3D Reality Model

c. Copy the Sample Photographs – Dataset Name: Barn (19 Photos) to a desired Location



d. Pictured are the steps required to produce a 3D reality model.



Creating a new project

1. Launch ContextCapture Master





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	New project	
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Get started with our <u>video tutorials</u>		e e
Learn more about ContextCapture		tems, l
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		Copyright © 2017, Bentley Systems, Inc.
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Desktop/Trial edition v4.4.0,351		Cop

2. Enter name and location of the project.

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Project location	n C:/Temp		Browse
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Importing your data

3. Open the photo tab and browse your photo dataset using "Add photos" or "Add entire directory."

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4. The photos have been imported in a photogroup. The camera sensor size and focal length have been extracted from the EXIF info and from the ContextCapture camera database.

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(Optional) scale, axis, or plan constraints setting

Without geo-referencing information, the resulting model cannot be scaled or correctly oriented. (ContextCapture will try to find the vertical of your scene when information is unavailable, but it is not always successful.)

The user can add scale and axis constraints before the AT (aerotriangulation)process to scale and rotate the block.

5. To do so, open the Tie Points tab.





Tie points	
	0 automatic tie point(s).
	View automatic tie points
Positioning constraints	
	×

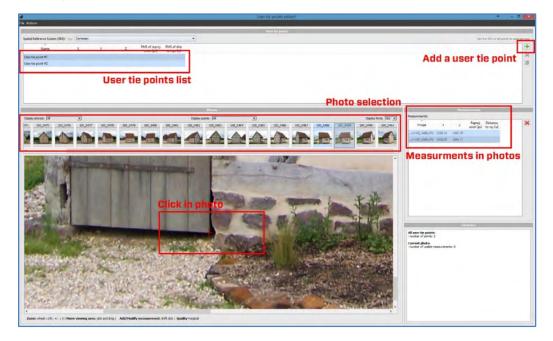




6. Click on Edit user tie points to open the User Tie-point Editor

To define a scale or an axis constraint, you will need to create two user tie points.

- To create a user tie point, click on the green cross at the upper right-hand corner.
 Highlight your tie point and pick the photos you want to measure. Click your points in at least two photos.









- 9. Once your two points are correctly selected in the photos, *save* and *close*.
- 10. To define a new constraint using these tie points, from the Positioning Constraints panel click on the green cross in the Tie Points tab.

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To set a scale constraint choose "add scale constraint."

11. Select the two tie points that will be used to define the scale constraint and define the distance between the two tie points.

9	P	ositioning constraint properties	×
Scale co	nstraint		
Select two	points A and B an	d specify the distance between them:	
Point A:	User tie point #1		•
	User tie point #2		•
Distance b	etween A and B:	2.3	units
		ОК Са	ncel





12. Click on OK to save the scale constraint.

You can add different constraints (axis and plan) using the same tie points or by adding other user tie points.

13. Adding an axis constraint:

9	Positioning constraint properties	×
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Processing the aerotriangulation 14. Return to the General tab, and select *Submit aerotriangulation*.

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General Photos Control points Tie points 30 view		
Incomplete photos You can estimate missing photo information by aerotriangulation.		Submit aerotriangulation Process a new block with completed or adjusted parameters.
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15. The aerotriangulation definition window will pop up.

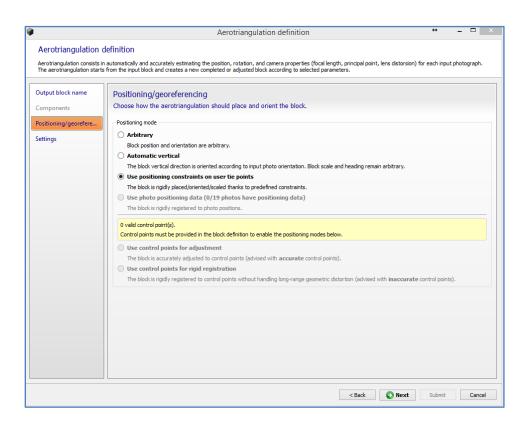
Aerotriangulation definition	^
Aerotriangulation definition	
Aerotriangulation consists in automatically and accurately estimating the position, rotation, and camera properties (focal length, principal point, lens distorsion) for each input p The aerotriangulation starts from the input block and creates a new completed or adjusted block according to selected parameters.	hotograph.
Output block name Output block name	
Components Choose the name and the description of the aerotriangulation output block.	
Positioning/georefere ID: Block_3	
Settings Pare Block_1 - AT Description Des	
Description Result of aerotriangulation of Block_1 (2015-Oct-01 16:48:45)	
< Back Submit	Cancel





Change or leave the default name for the new block that will be created.

16. In the positioning/georeferencing page, select the mode you want to use. If you have defined tie point constraint "use positioning constraint on user tie points." Otherwise, choose "automatic vertical" to let the software try to determine automatically the Z axis of the scene. (Warning: your model will not be scaled using this mode.)







17. In the settings page, leave the default settings and press submit.

Output block name						
	Settings					
omponents	Choose aerotriangulation setti	ngs including estimatio	on policie:	s and low-level settings.		
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	Optical properties estimation mode	One-pass	•			
	Focal length	Adjust	•			
	Principal point	Adjust	•			
	Radial distortion	Adjust				
	Tangential distortion	Кеер	-			
	Estimation groups	Per photogroup	•			

18. The AT is now pending and ContextCapture Master is waiting for the Engine to process the job.



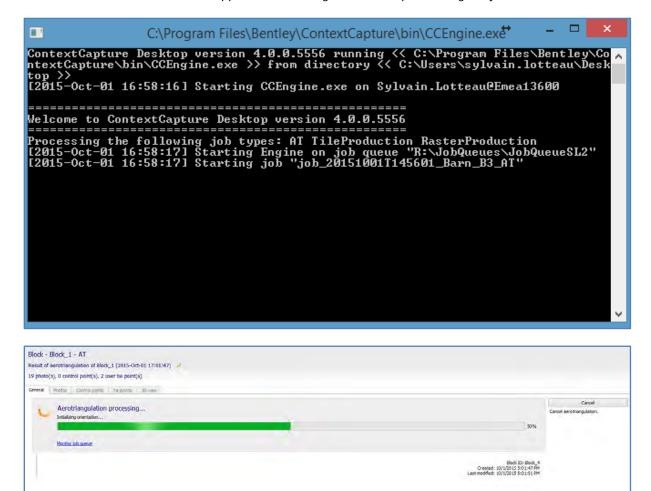
19. Make sure that the ContextCapture Engine is launched from the desktop icon.



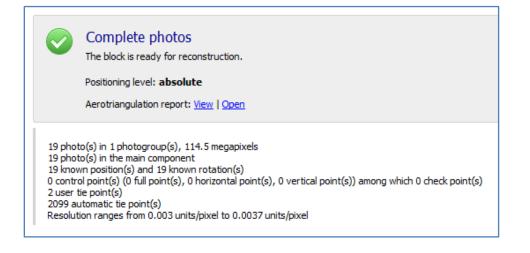




20. A command window will appear and the Engine will start processing the job.



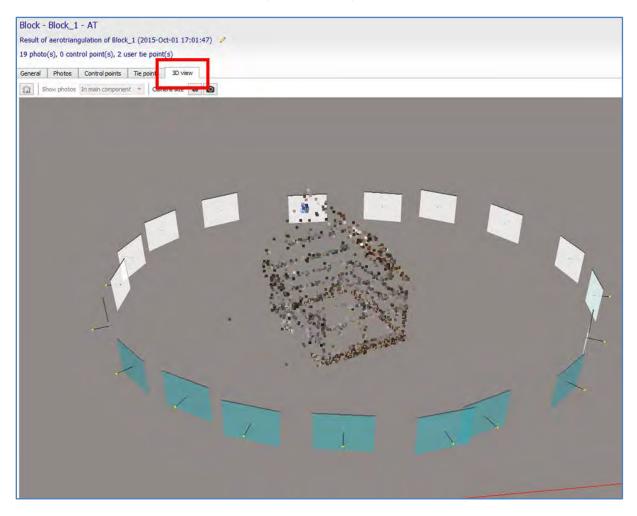
21. Once the AT is done the status becomes "Complete photos"







22. Click the **3D view** tab to check the position of the photos.



The displayed points are the automatic tie-points used by ContextCapture to link the photos together.

JobQueue Issues

Note: You may encounter problems when submitting your jobs. This might be the result of the JobQueue not being accessible because of permission issues, **("fail to submit aerotriangulation")** or the Engine module may be listening to the wrong JobQueue ("warning: there is no engine currently listening to the JobQueue").

If you are experiencing these issues, please **reset the JobQueue** to a directory where you have read and write access (typically the "My Documents" folder is OK).





Changing the JobQueue

Launch ContextCapture Settings

("C:\Program Files\Bentley\ContextCapture\bin\CCsettings.exe").

Go to the "Configuration" tab and browse your new JobQueue.

	ContextCapture Settings	×
License Configurat	tion System information	
Job queue Define the default jol Job queue directory:	z:\JobQueue Browse	

23. Once this step (JobQueue) is completed, submit the aerotriangulation again to complete the 3D view of the photographs.





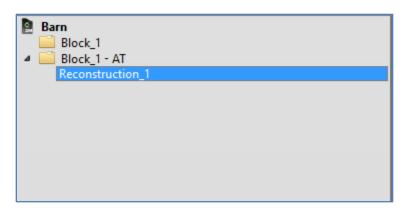
Creating a new reconstruction

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

24. To create a reconstruction, return to the general tab and click "Create reconstruction."

	ContextCapture Master - Deskt	top edition [Barn.ccm*]	- 0 ×
Project Block Reconstruction Production Tools Help			
			context conture TM
1- PHOTOS 2- CAMERA PROPERTIES 3- AEROTRIANGULATION	4- ABCONSTRUCTION SETTINGS S- PRODUCTION	You can create a new reconstruction.	×
Barn + Block_1 - AT +			
Eten Bog 1 Mag 14	Block - Block_1 - AT Result devotriansplation of Block_1 (2015-0ct-01 17:01:47) 19 photor(), 0 control point(s), 2 user te point(s) Terment Result Control point(s), 20 ver Complete photos Te points user for recommunitor. Prationage tradit absolute		Submit excisiongulation Process a new block with completed or adjusted parameters.
	A estranguidation report: Elect Decel 19 doct) in 19 doctor profil: (1): (13 doctor hand) 19 doct) in 19 doctor hand (1): (13 doctor hand) 19 doctor hand) (12 doctor hand) (13 doctor); (13 doctor hand) (13 doctor hand) (13 doctor hand) 10 doctor hand) (12 doctor hand) (13 doctor hand) (13 doctor hand) (13 doctor hand) (13 doctor hand) 19 doctor hand) (13	2004 13 2004 Created 30/2015 55:1794 Last modified 30/2015 500 2294	
			Color reconstruction Online research without Knewson reconstruction from block

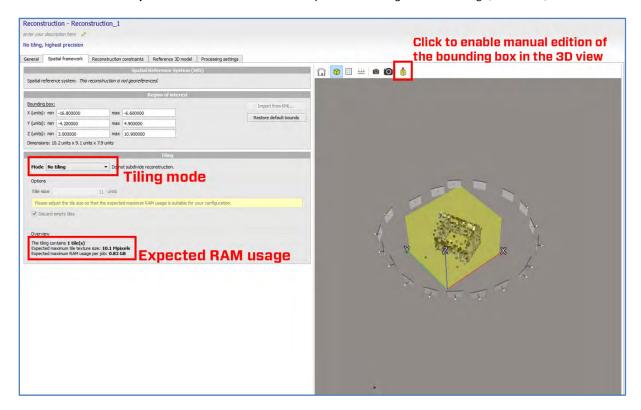
25. A new **reconstruction** is created in your block. Several reconstructions can be created, with different settings.







26. Go to the "Spatial framework" tab to setup the bounding box and tiling (if needed).



27. To change processing settings, click "processing settings."

Reconstruction Reconst	auction 1				
	Reconstruction - Reconstruction_1				
enter your description here 🧳					
No tiling, highest precision					
General Spatial framework R	econstruction constraints Reference 3	D model Processing settings			
Preset type: Default 🔻					
Selection of matching pairs	Generic 💌				
Geometric precision	Highest 👻	Highest precision, larger file size (tolerance of 0.5 pixel in input photos)			
Hole-filling	Fill small holes only				
Geometric simplification	Standard 🔻				
Color equalization mode	Standard 👻				
Untextured regions representation	Inpainting completion 💌	Untextured regions color:			
Low-level settings					
No item defined.					

28. Once your reconstruction framework is setup, return to the general tab to submit a new production.





Submitting a new production

Project Block Reconstruction Production Tools Help	ComperCapture Matter - D	etitop edition (Sam conv)	
Project Block Reconstruction Production Tools Help			
I THATOS I DANTER PROFESSION & ADDRESS AND ADDRESS		You can modify the reconstruction spatial framework and processing settings before starting production.	
Barn + Bock_1-AT + Reconstruction_1 +		FOR THE DESIGN THE PERMIT REPORT STREET, BAR AND BACK SHE PART SHE WITH THE PERMIT.	
In - Ku, - K - Konnek, -	Reconstruction - Reconstruction_1 Provide International Control of Control o	Manufactor D. Garantee, r.J. Landre 10003 3 1 1 1 7 4	State are posicitate.

29. The production definition window is displayed.

¥	Production definition	- 🗆 🗙
Production definition	1	
Define parameters of the new	production.	
Define parameters of the new Name Purpose Format/Options Spatial reference system Extent Destination	production. Name Enter production name and description. ID: Production_1 Name Production_1 Description	
	< Back Submit	Cancel





30. In the purpose page, choose the purpose of your production.

¥	Production definition – 🗖 🔼				
Production definition	n				
Define parameters of the nev	v production.				
Name	Purpose				
Purpose	Choose the purpose of the production to submit.				
Format/Options	Purpose of production				
Spatial reference system	30 mesh				
Extent	Produce a 3D model optimized for visualization and analysis in third-party software. Produce the reference 3D model too.				
Destination	3D point cloud Produce a colored point cloud for visualization and analysis in third-party software. Produce the reference 3D model too.				
	Orthophoto/D5M Produce interoperable raster layers for visualization and analysis in third-party GIS/CAD software or image processing tools.				
	30 mesh for retouching				
	Produce and export the reference 3D model for editing in a third-party software and importing back into ContextCapture Master for later productions. A margin is specially included.				
	Reference 3D model which can be used only inside ContextCapture Master, for quality control and as a cache for later productions. The reference 3D model is needed for orthophoto/DSM productions.				
	< Back Submit Cancel				

31. In the Format/Options page, choose the **format/options** for the specific purpose.

¥	Production definition -	×
Production definition	-	
Name Purpose	Format/Options Choose output format and options for the production.	
Format/Options Spatial reference system	Format: ContextCapture 3MX SD multiresolution mesh format, optimized for exchange with Bentley applications.	
Extent	Web ready Include proxy 3D model	^
Destination	Generate Acute3D Web Viewer application Generate Acute3D Web Viewer application Include texture maps Texture compression: 75% quality JPEG Maximum texture size: 8192 pixel Level of detail (LOD) Type: Adaptive tree Node size: medium (~35 kB/node) Skirt: 4 pixel	
	< Back Submit	Cancel





32. Select the destination folder and click "submit."

¥	Production definition	- 🗆 🗙
Production definition	1	
Define parameters of the new	production.	
Name	Destination	
Purpose	Choose the production location.	
Format/Options	Output directory	
Spatial reference system	Directory C:/Temp/Barn/Productions/Production_1	Browse
Extent	We recommend you to select an empty directory to avoid overwriting existing production results.	
Destination		
	< Back 🔊 Next 📀 Sub	mit Cancel

33. Select your production in the project tree to see the progress of the process, until it is completed.

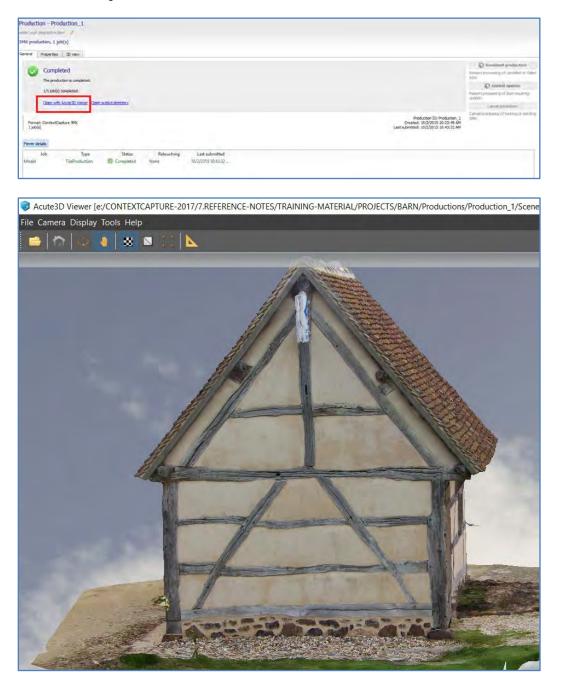
Block_1 Block_1 - AT Reconstruction_1 Reconstruction_1	Production - Production_1 and provides and p		
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	(V) () (b)()) completed. Does output directory (Monitor sole output		Restart processing of jobs requiring update.
	Formal-Context-Sphere 366 13650	Production ID: Productor, I Created: 10/2/2015 10:22-94 AM Last submitted: 10/2/2015 10:43:32 AM	Cancel processing of running or pending jobs.
	ber Type Sahan Betworking Law sahamited Nodel TaleProduction ⁽¹⁾ ik Running (5%) Hisne 10(2)(2013 10:4332		





Visualizing the production

34. Launch **Acute3D viewer** or visualize the 3D model in the 3D view tab (only works for S3C 3MX and single-tile OBJs).





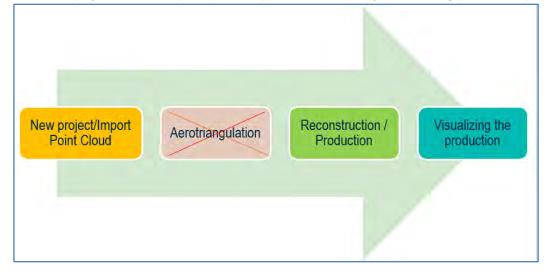


Workflow 2: Using Point-cloud data to Create a 3D Reality Model

1. Copy the Sample – Dataset Name: Point cloud **Tuxford_referenced_scan.e57** to a desired location.

context capture ™	B
Learn	Create Start a new project New project
Get started with our <u>video tutorials</u>	Open an existing project Open
Learn more about ContextCapture Desktop/Trial edition v4.4.0.351	Copyright El 2017, Ban tiby Systemme, Inc.

2. Displayed are the steps required to produce a 3D reality model using photos and point-cloud data.







Creating a new project

- 3. Launch ContextCapture Master
- 4. Enter name and location of the project

4	Contestap	pture Maiter - Desktop edition (liam ctm)	
Project Eleck Reconstruction Sectors Taols Help			
THERE I CHARLENDER IN A PROPERTY OF	of the second	Empty black. Add physics into the black to proceed	×
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	Rear gin the Treatment and an additional to the block.		
Project Tree			Chererconstruction Cathe Level House A. Cher & Samuel K. Solitie Houselike Ker- Rennin Industrial Sciences Industrial Rennin Industrial Sciences Industrial

Importing your data

5. Open the **Point clouds** tab and browse to your LiDAR dataset and **Import Point Cloud** (only PTX and E57 file formats are supported).

General Photo	s Point clouds	Surveys	Additional data	3D view			
<table-of-contents> Import point c</table-of-contents>	oud 👯 Remov	e point cloud					
Name	Descriptio	n					
		🗊 Import p	oint cloud		×	1	
		Select a file	and check its spatia	l reference system.			
		Open file: 4_	data_package/Photo	s+Lidar/Tuxford_ref	erenced_scan.e57 🔒		
			rence system	. . .			
	Non-georeferenced cartesian coordinates system Edit Spatial reference system						
				0	K Cancel		





- 6. Click on "Edit spatial reference system" and select from More "Spatial reference system database"
- 7. In the filter, search for EPSG:4978

Spatial r	reference sys	tem databas	se			>
Select a spi	atial reference	system from t	the database.			
		1				
	o create your	own definition	by creating n	ew user defi	ned system.	
Filter						
epsg:4978	Туре	All			•	Clear all filters
Spatial Refe	erence System	ns: 1 items				
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Selection						
Non-geor	eferenced c	artesian cooi	rdinates sys	tem		
Туре	User defined	systems				
Definition	Local: 0					Edit
					ОК	Cancel

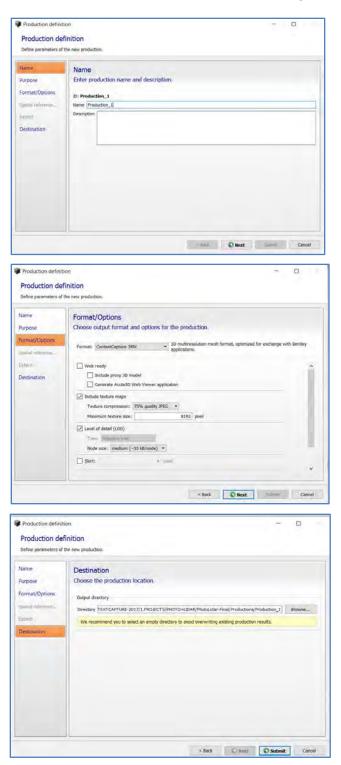
- 8. Click OK
- 9. Now, click on the General Tab again and click on "New reconstruction."





Submit new production

10. Just follow the Production Definition Settings



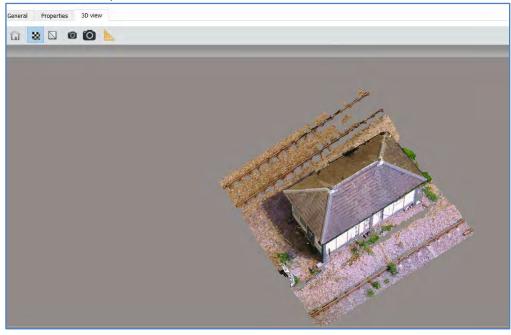




11. Click on "Submit"

Protocial-Field Book Book Resembling Resemb	Production - Production 1 array are represented and array and 3955 productions 1 (xd(s)) Grand Typerson 20 alway Represented and array of the second Free production in running. Represented array of the second Free constants Free constants Free constants Free constants	276 Provideo B. Problem Contect Do Server 37 23 5 Fit Lat subortical: 35 Nor 17 8 13 PH Lat subortical: 35 Nor 17 8 13 PH	C Instant praiden Instant and a sended to lead Sector and the sended of lead Sector protection Configuratio
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Format: Context 1 job(s) More details	ICapture 3MX		Production ID: Production Created: 05-Mar-17 8:15 Pl bmitted: 05-Mar-17 8:18 Pl

12. Once Completed select the "3D View" tab

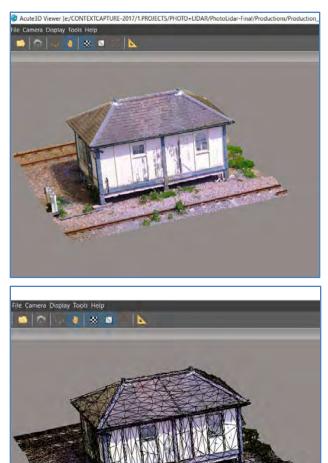






Visualizing the production

Launch Acute3D Viewer and open the Output file



Conclusion:

- With ContextCapture, you can quickly produce the most challenging 3D models of existing conditions for infrastructure projects of all types, derived from simple photographs.
- Without the need for expensive, specialized equipment, you can quickly create and use this highlydetailed 3D reality meshes to provide precise real-world context for design, construction, and operations decisions for use throughout the lifecycle of projects.
- You can reliably and quickly produce 3D models of any scale, from objects of a few centimeters to entire cities using ContextCapture.
- There is no limit in the precision of the resulting 3D model, other than the resolution of the input photographs.