

***Technologies for Spatial Heritage Documentation - Should
documentation be driven by needs or by technologies.***

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Abstract

The presentation discusses the use of state-of-the art technologies in heritage documentation based on experiences gained while documenting heritage sites for the African Cultural Heritage Sites and Landscapes database. The advantages and shortcoming of terrestrial laser scanning and Structure-from-Motion methods as applied to 3D modelling are briefly explored and the combination of these data types and other technologies in Virtual Tours of heritage sites is discussed.

Thoughts and observations on Heritage Documentation



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Presentation

- 1. General comments on Heritage Documentation**
- 2. Examples from the African Heritage Project**

Why spatial documentation ?

Application areas of Spatial Data

- **Conservation**
- **Restoration**
- **Virtual reconstruction**
- **Research (architecture, social and physical anthropology, archaeology, history)**
- **Site management**
- **Records for future generations**
- **Visualisation (education, awareness creation tourism)**

Destruction through war



Timbuktu 2012

Destruction through war

News Sept. 2012: [Heritage site destroyed in battle-torn Aleppo](#)



6 of Syria's 7 World Heritage Sites in danger

Destruction through mining operations



Mes Aynak Afghanistan

Natural decay

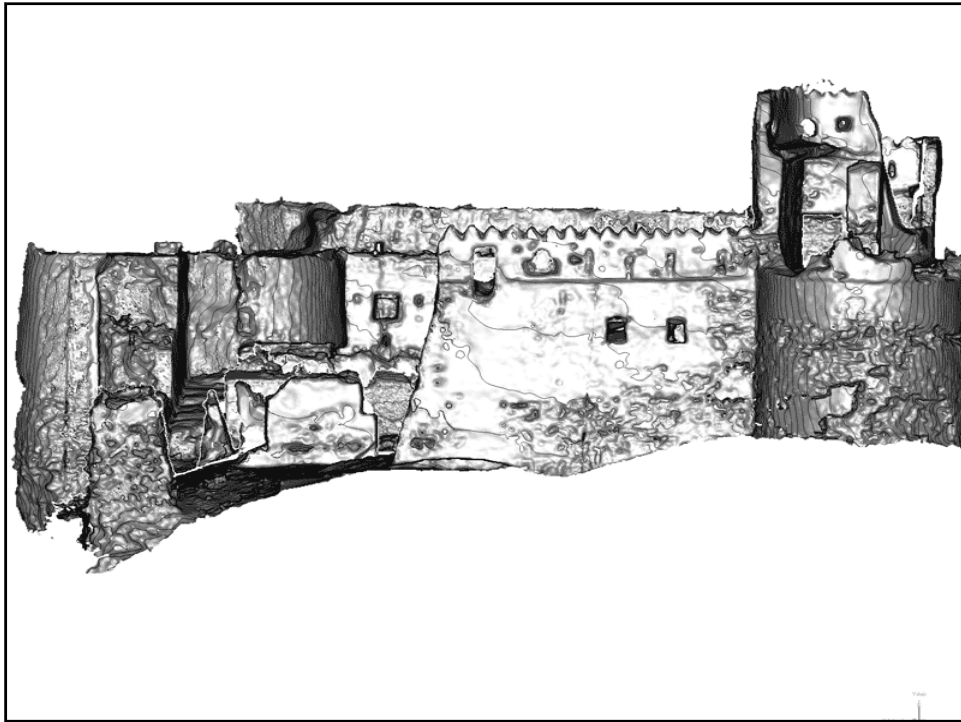
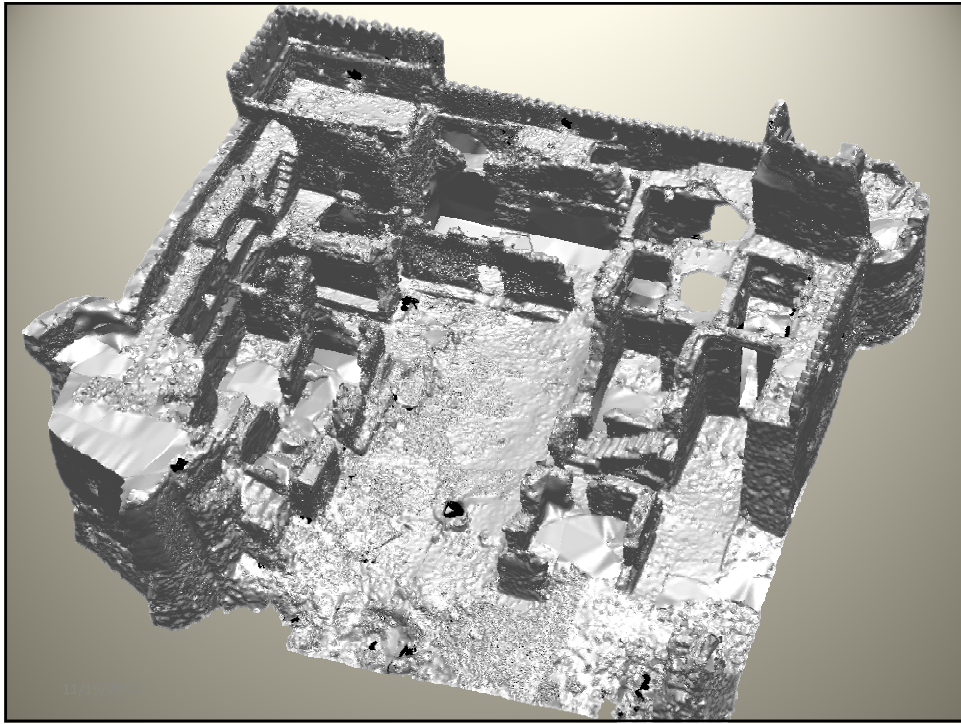


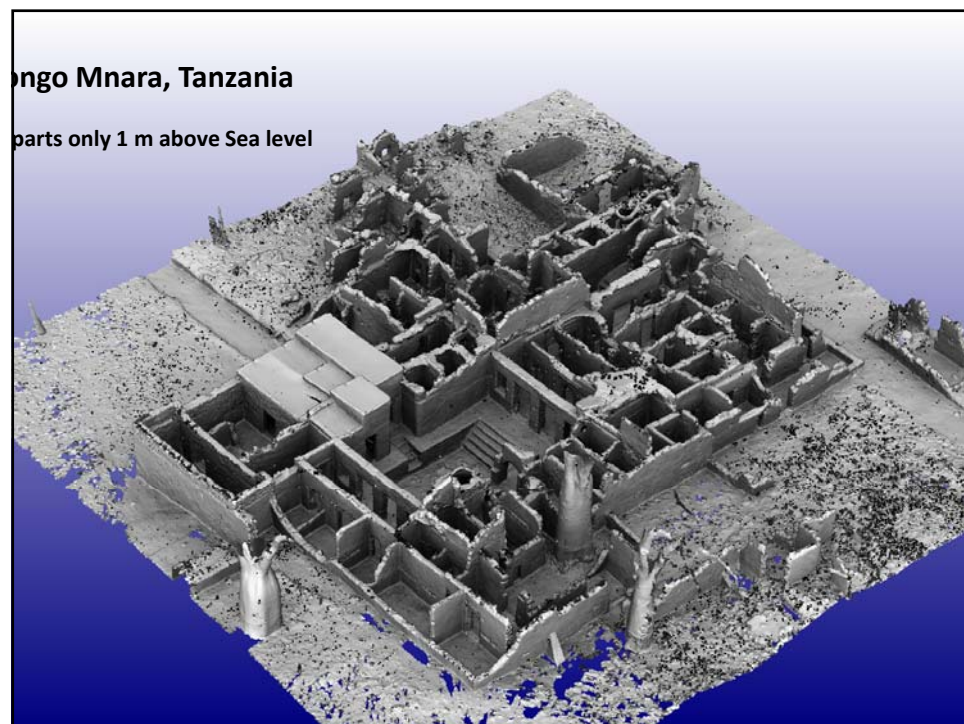
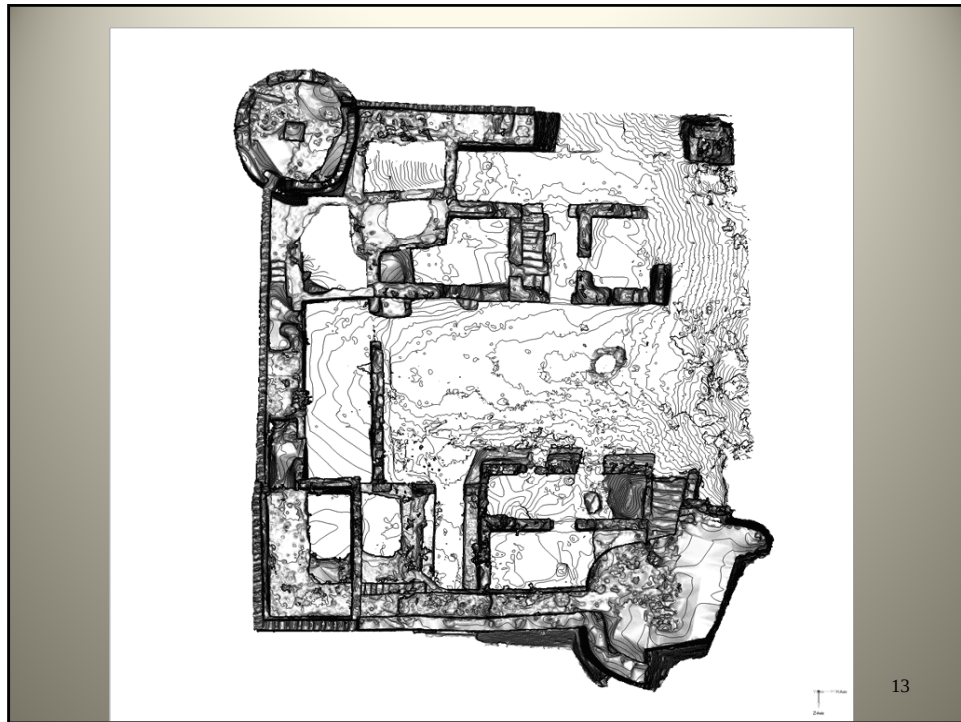
Kilwa Kisiwani Collapsed Entrance

Threat from sea level rising

Kilwa Tanzania



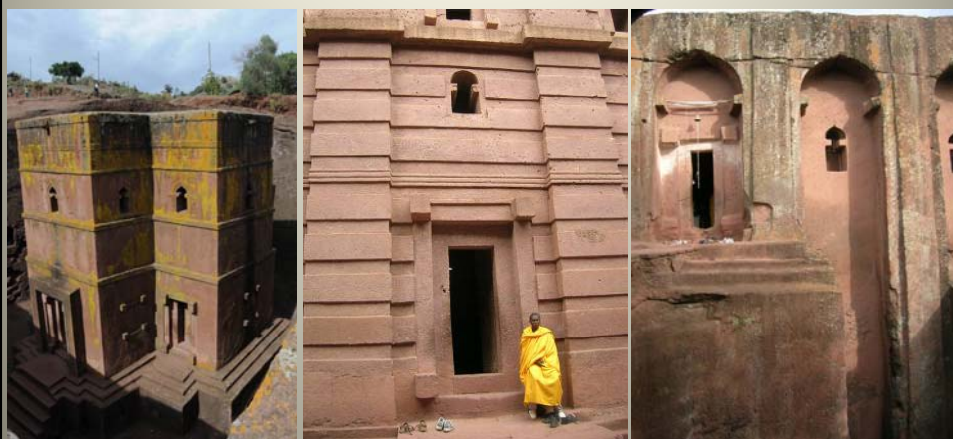




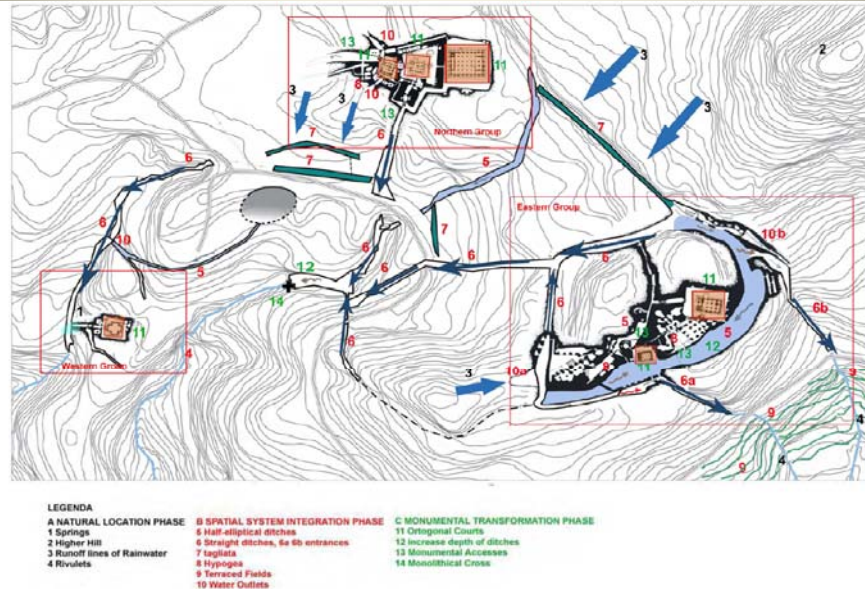
Lalibela, Ethiopia

A example of application in conservation

Lalibela, Ethiopia



Lalibela: elaboration of the GIS base and interpretation of chronological phases



Mapping cracks and monitoring devices in Biet Gabriel-Rufael

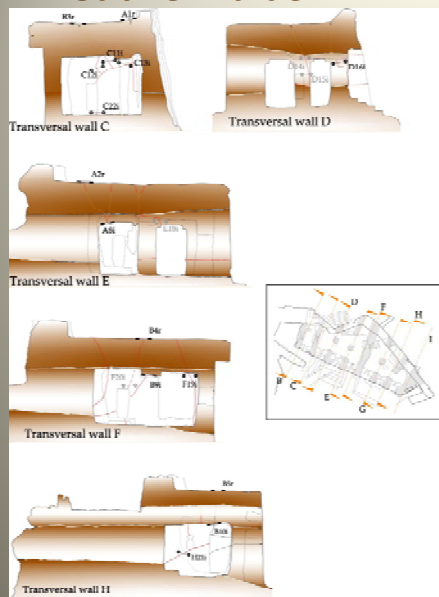


Fig.4. South elevation: Three types of fractures are evident; an old geological one (violet), a post excavation (blue), a structural one (red).

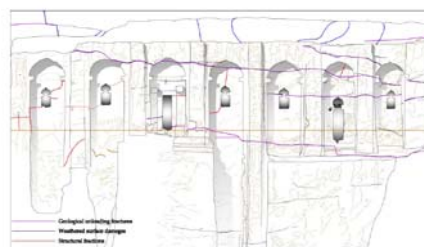


Fig.5. North elevation: Three types of fractures are evident; an old geological one (violet), a post excavation (blue), a structural one (red).

Choice of appropriate methods

The non-technical end user of spatial data is often not familiar with new technologies and the potential use of spatial information



- Tenders with inappropriate accuracy and spatial resolution requirements
- underuse of acquired data
- unrealistic expectation

Accuracy requirement

Typical request: As accurate as possible

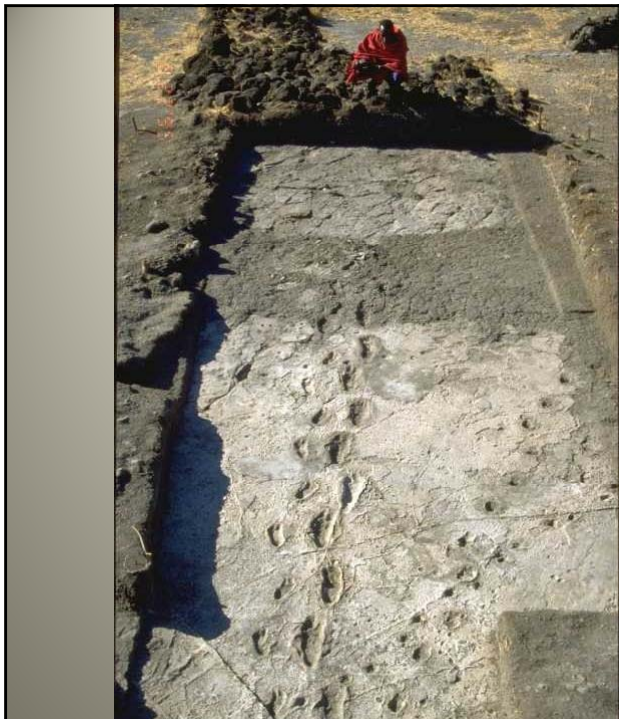
Actual need  Cost/time/effort

Needed:

- end user education
- development of appropriate output formats

Laetoli trackway, Tanzania

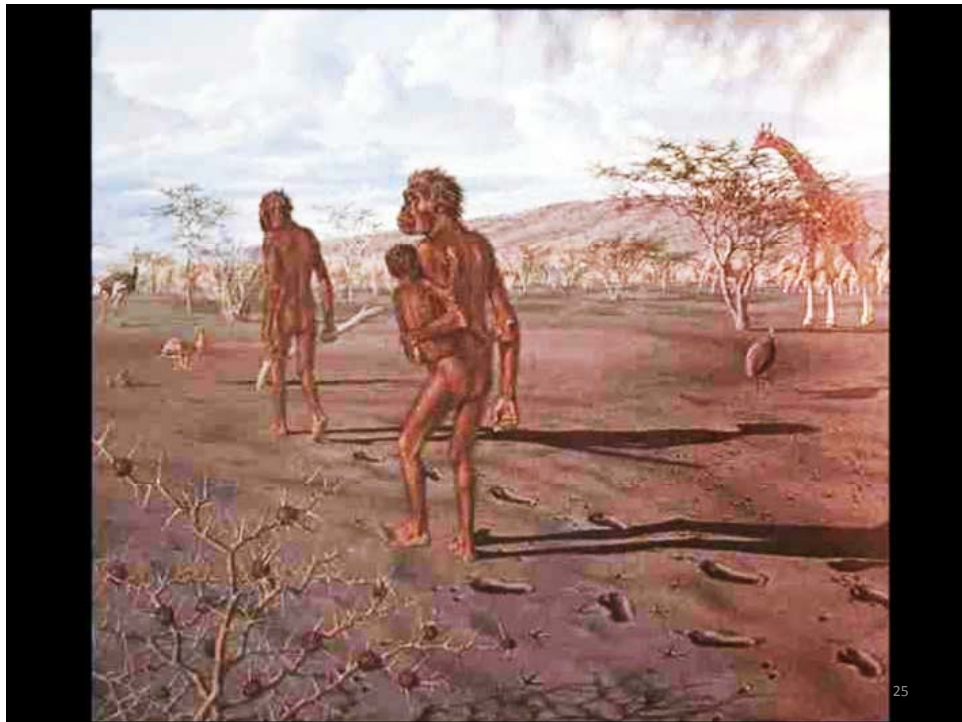
**A example of justifiable high accuracy
requirements**



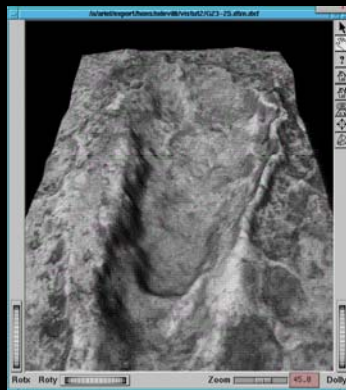
**Laetoli Trackway,
Tanzania**

Laetoli Foot Prints

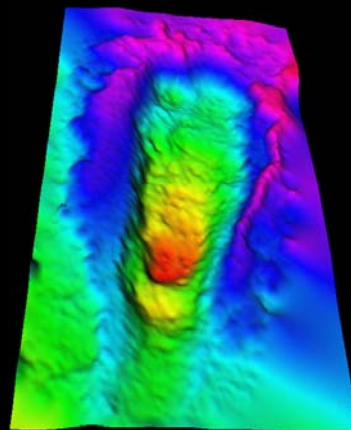




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Ortho photograph of footprint
draped over the 3D surface model
generated using photogrammetric
methods.

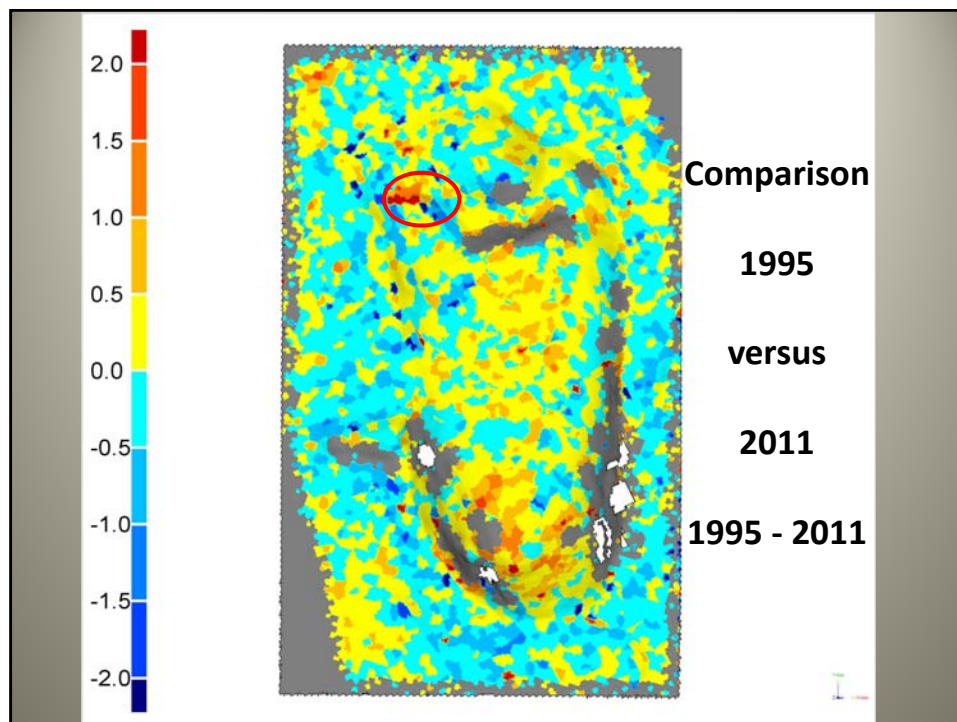


Colour coded 3D
representation
(different colour shows
different heights)



**2011
Re-excavation**





Crucial but often neglected

- technical quality control
 - uncertain or poor accuracy,
 - varying resolution,
 - subjective 3D modeling,
 - poor texturing
- questionable authenticity
(manufactured data)

Some problem areas

- Hole filling and manufactured data
- Deception by texture
- Subjective surface generation
- Need for data decimation
- Ignoring the need for meta data

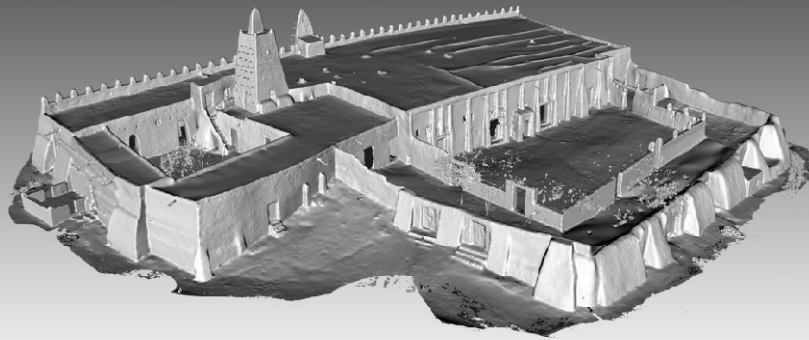
Filling of Scan holes



Hole filling and manufactured data



Djingereyber Mosque
Timbuktu, Mali

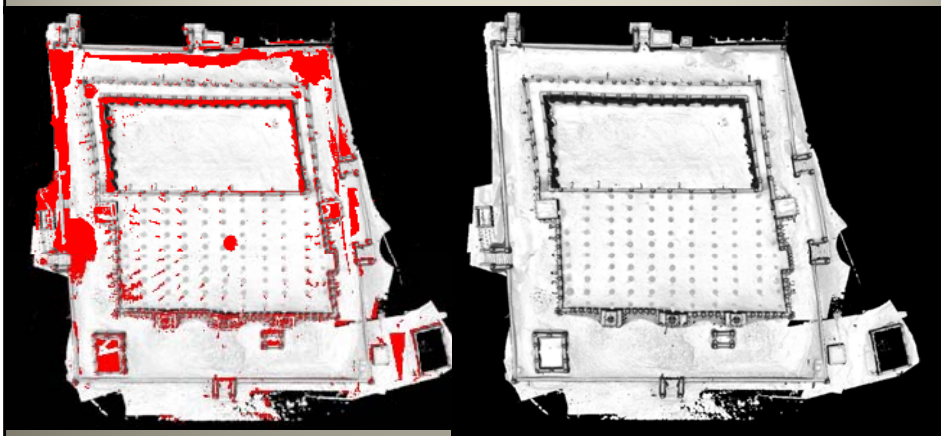


13:35

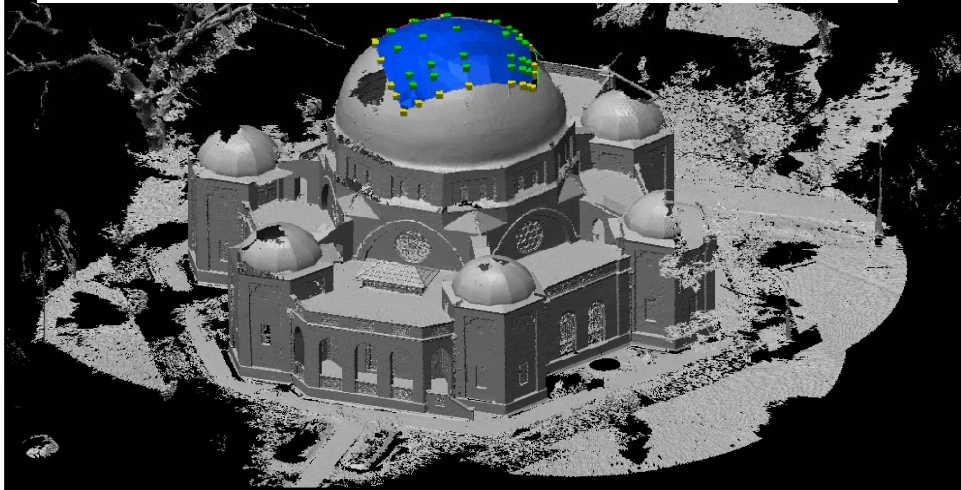
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Zamani Project policy

Provide two models, one as acquired and one filled



Generally scan holes cannot be completely
avoided
e.g. roof problem (UAVs)



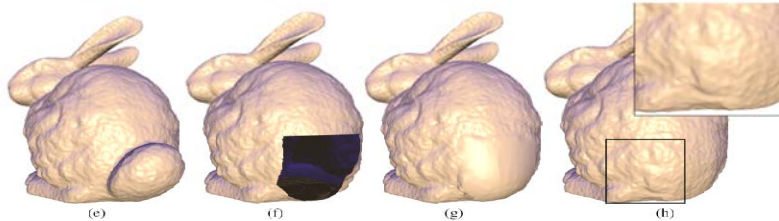
Surface Augmentation/ Hole filling

Context-based Surface Completion

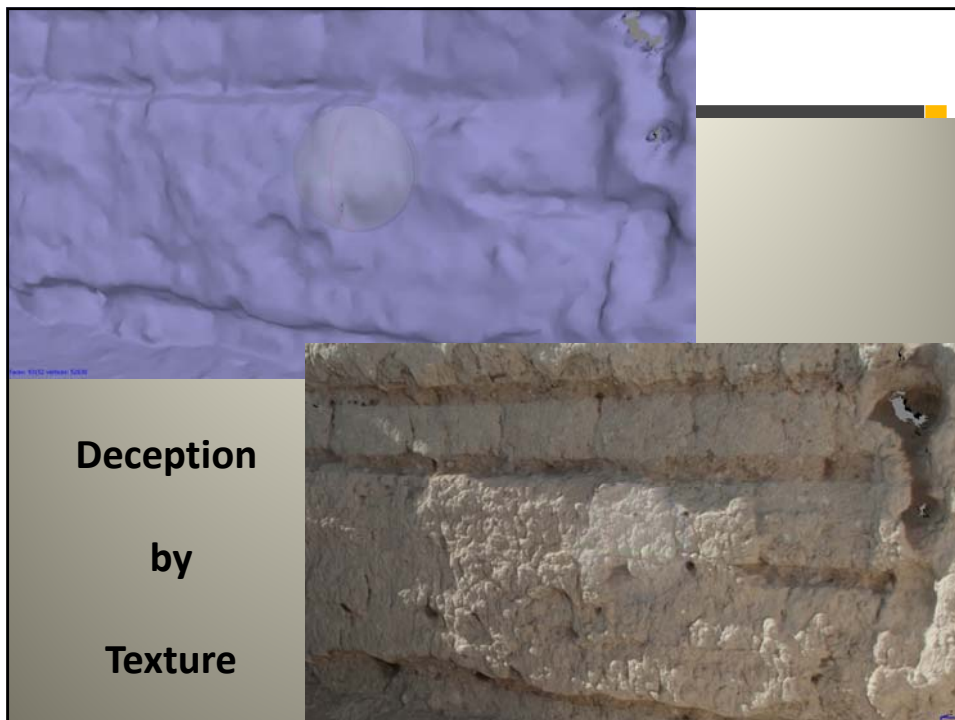
Andrei Sharf
Tel Aviv University

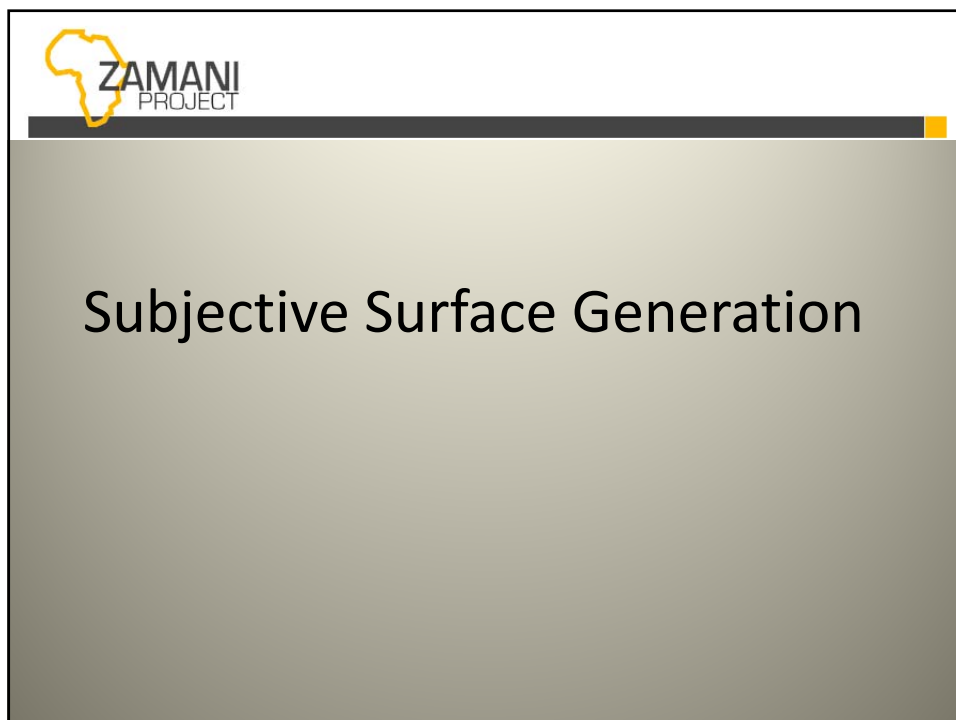
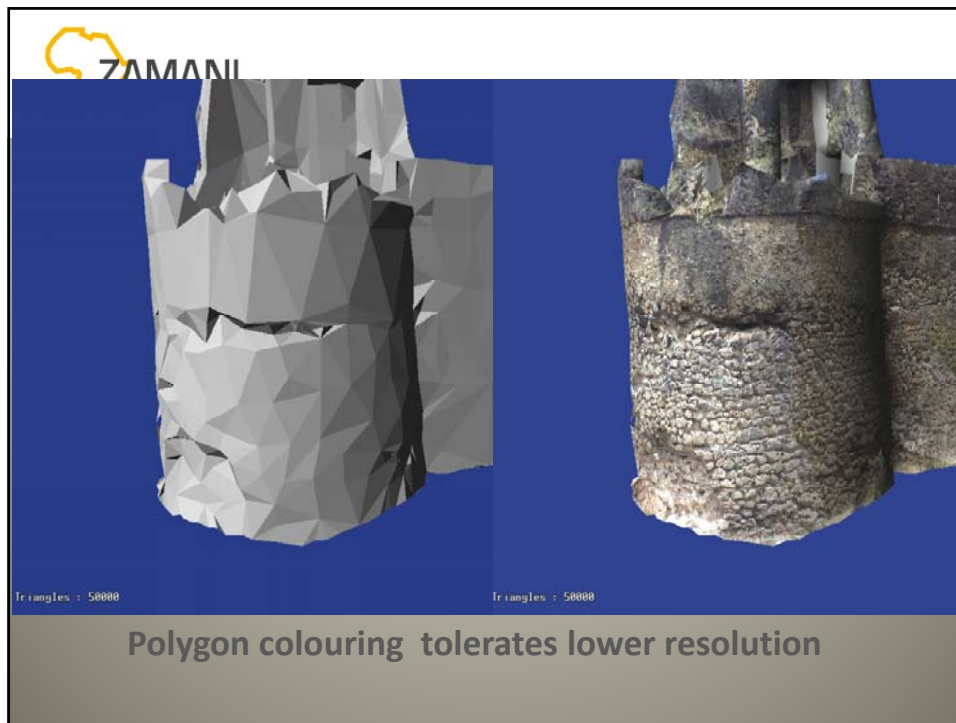
Marc Alexa
Darmstadt University of Technology

Daniel Cohen-Or
Tel Aviv University



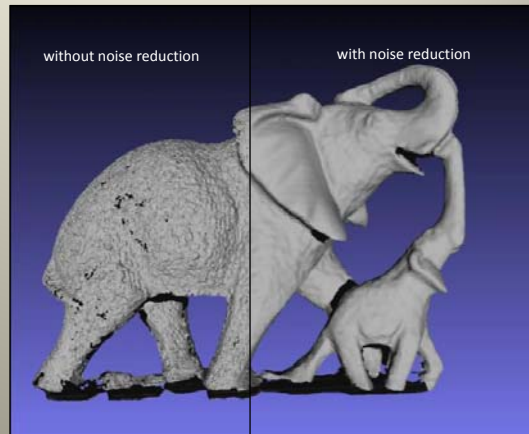
Deception by texture (colour)





Delaunay/Voronoi

- Works on arbitrary point input data, without information about point neighbours/good in overlapping areas
- Complexity grows almost exponentially with amount of points
- Usually not very robust to noise



Volumetric Integration

- Merges individual scans
 - Fast
 - Scalable
 - Robust
- Does not preserve details as it does make use of information about size of triangles in a voxel



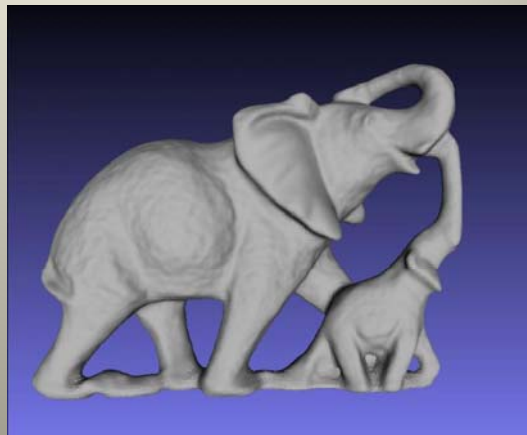
Moving Least Squares

- Works on a Point Set
- Current tools need pre-calculated normals



Poisson

- Fills holes
- Current implementation need pre-calculated normals
- Produces watertight surfaces
- Loss of detail

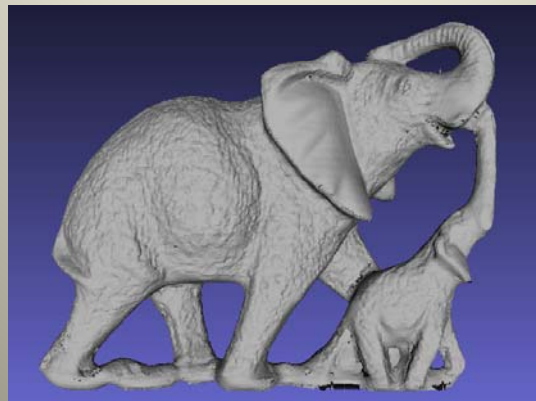




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None of the techniques seems to be sufficient
on their own

Best results from **merging different methods**



Surface Reconstruction

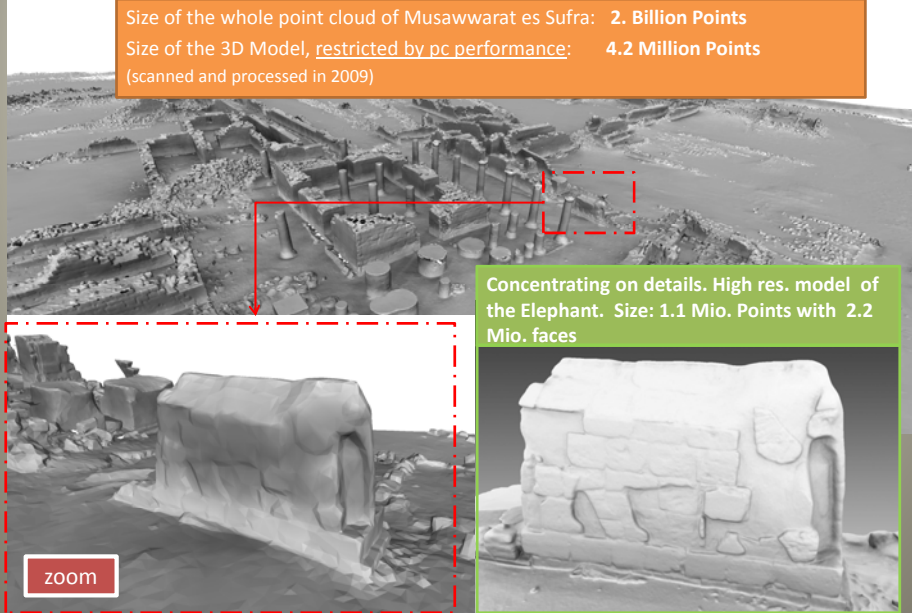
is not objective



Hardware Limitations

Limitation of modelling resolution

Size of the whole point cloud of Musawwarat es Sufra: **2. Billion Points**
 Size of the 3D Model, restricted by pc performance: **4.2 Million Points**
 (scanned and processed in 2009)



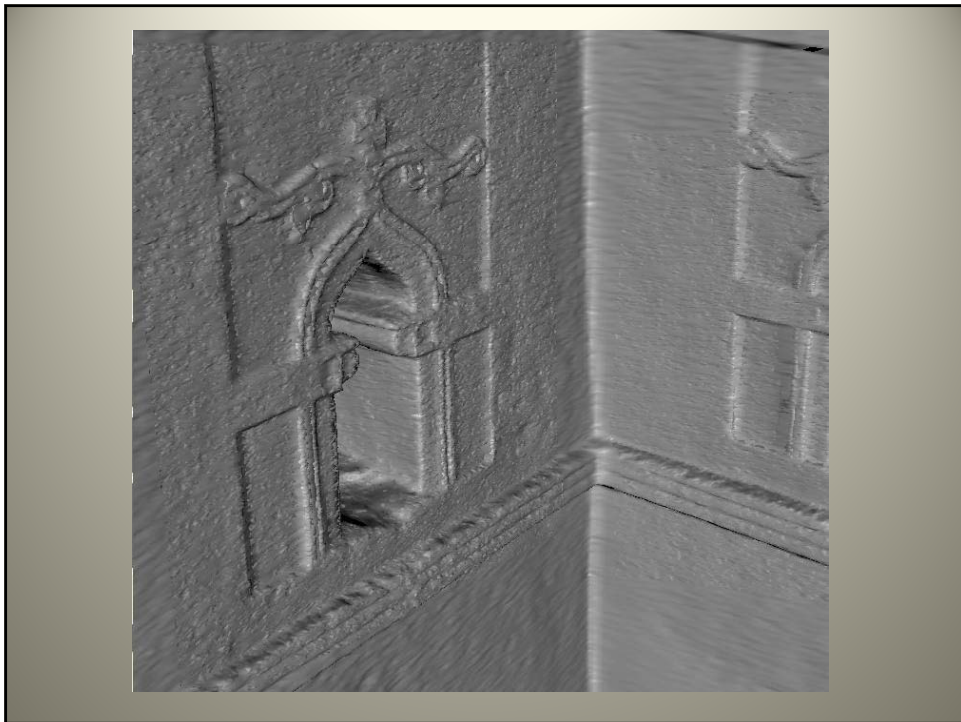
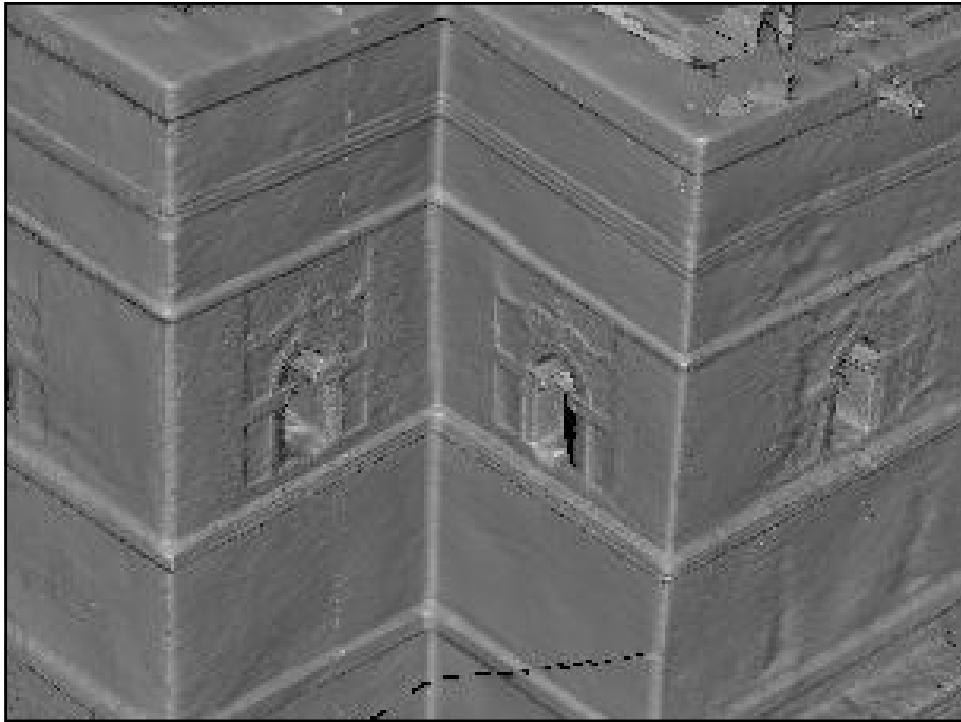
Limitation of modelling resolution

3D Model in very low resolution with 200,000 Faces built into a Virtual Tour of Gede – Great Mosque



3D Model in high resolution with 5 Mio Faces

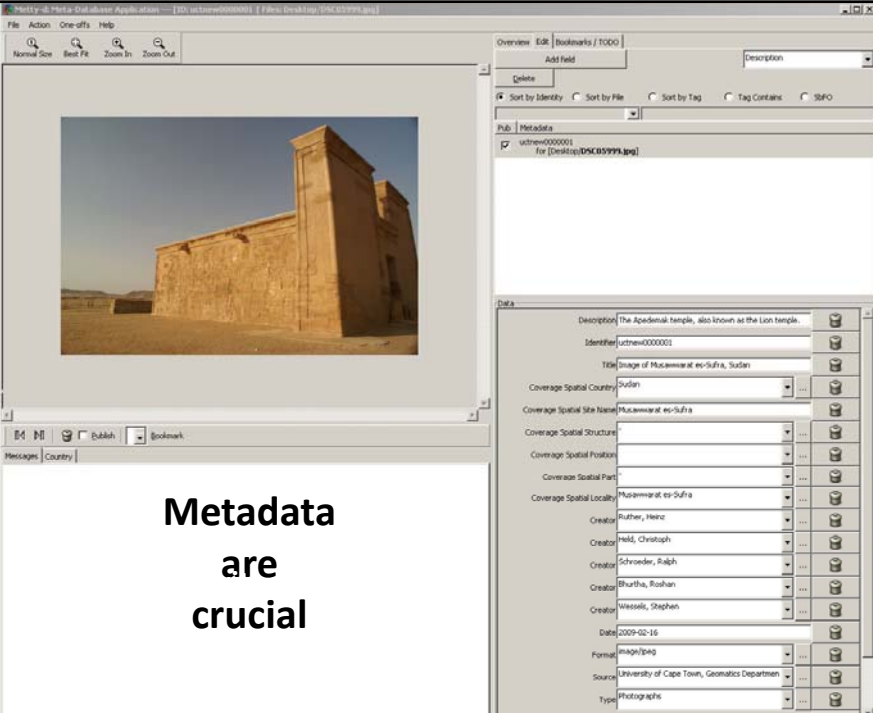




Metadata

Detailed meta data are
essential
for
databases

**Metadata
are
crucial**

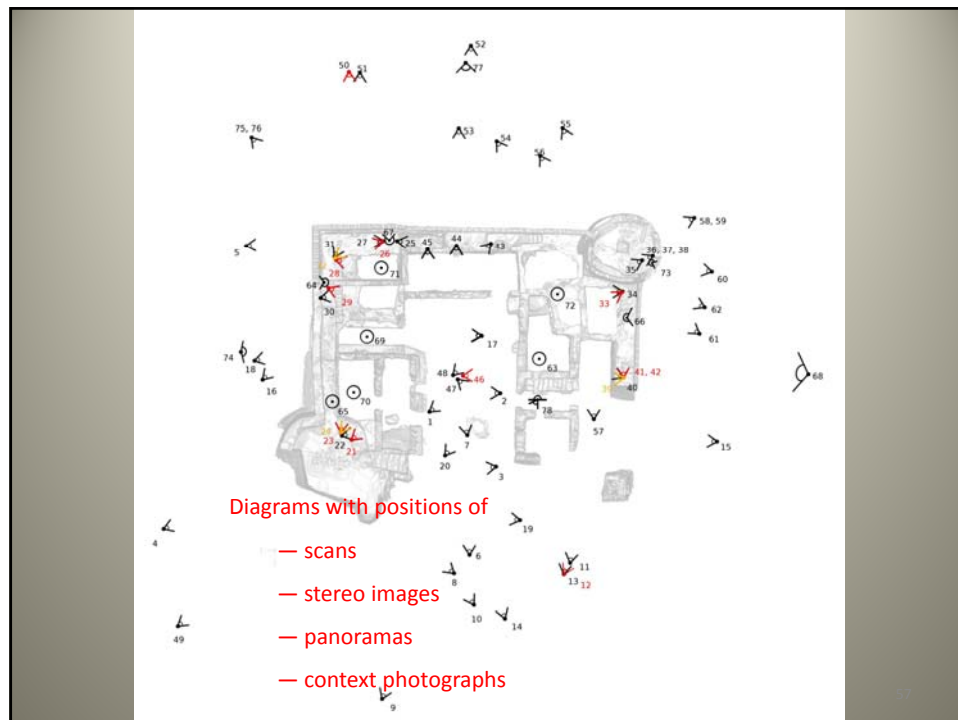


The screenshot displays a software application window titled "Partly-UI: Meta-Database Application". The interface is divided into several sections:

- Top Bar:** Includes a menu bar (File, Action, One-offs, Help) and a toolbar with icons for Normal Size, Best Fit, Zoom In, and Zoom Out.
- Main View:** A large central area displaying a photograph of a stone temple structure.
- Right Panel:** Contains a "Metadata" section with a "Delete" button and a "Sort by" dropdown menu. Below this is a "Data" section with a list of metadata fields and their values.

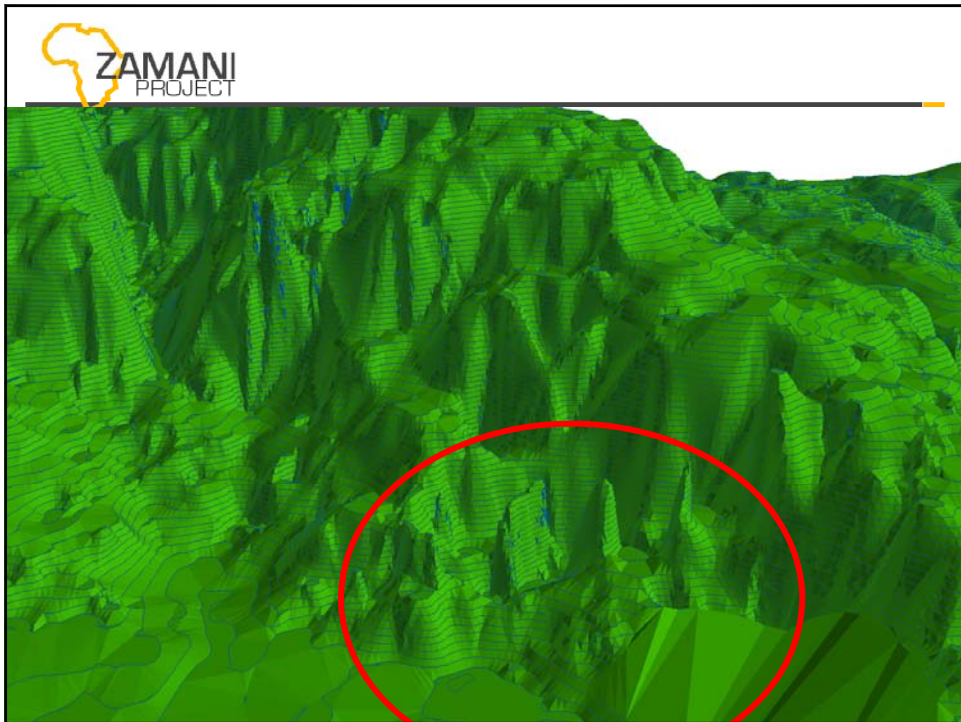
The "Data" section lists the following metadata:

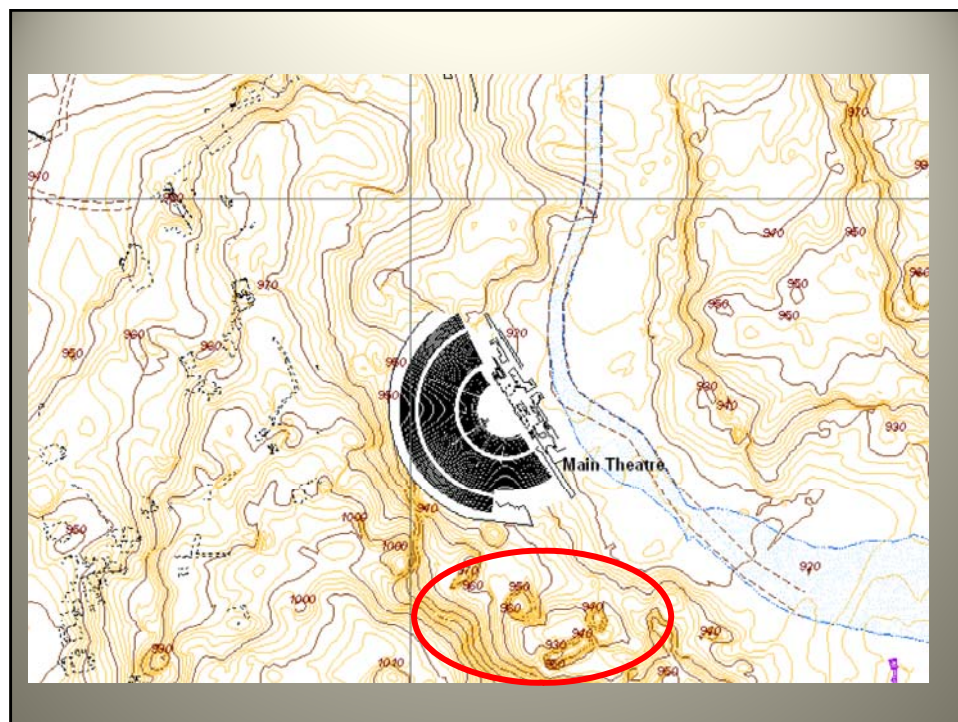
Field	Value
Description	The Apedemal temple, also known as the Lion temple
Identifier	utdmw0000001
Title	Image of Muqammarat es-Sufra, Sudan
Coverage Spatial Country	Sudan
Coverage Spatial Site Name	Muqammarat es-Sufra
Coverage Spatial Structure	
Coverage Spatial Position	
Coverage Spatial Part	
Coverage Spatial Locality	Muqammarat es-Sufra
Creator	Rutten, Heinz
Creator	M&A, Christoph
Creator	Schneider, Ralph
Creator	Bhurtha, Roshan
Creator	Wesselt, Stephan
Date	2009-02-16
Format	image/jpeg
Source	University of Cape Town, Geomatics Department
Type	Photographs



The Dangers of Automation

Blind trust in Technology





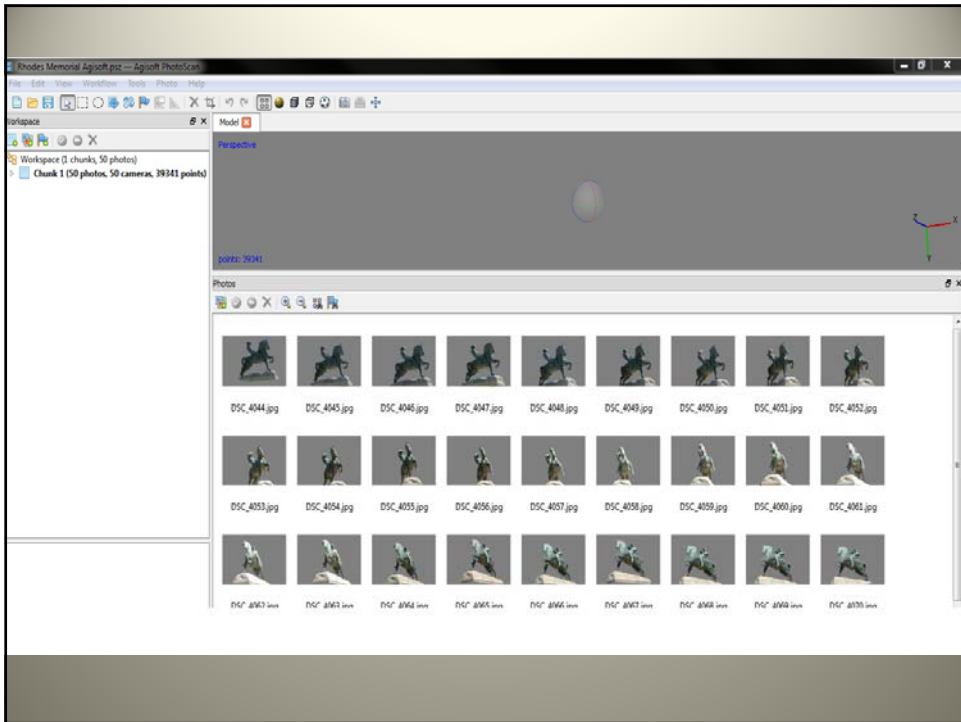
Structure from Motion SfM

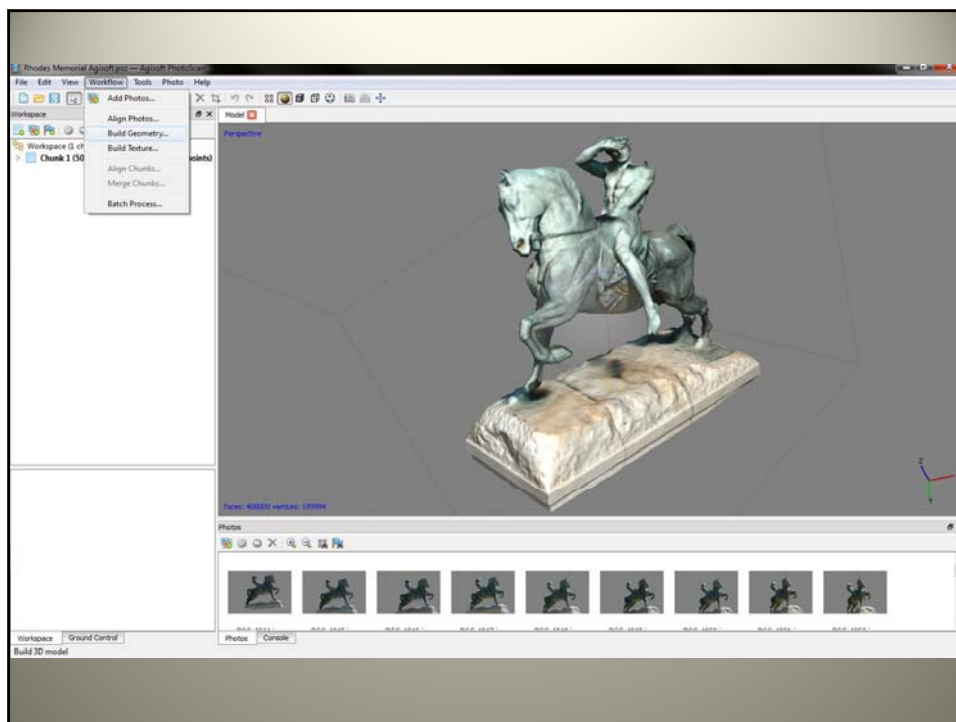
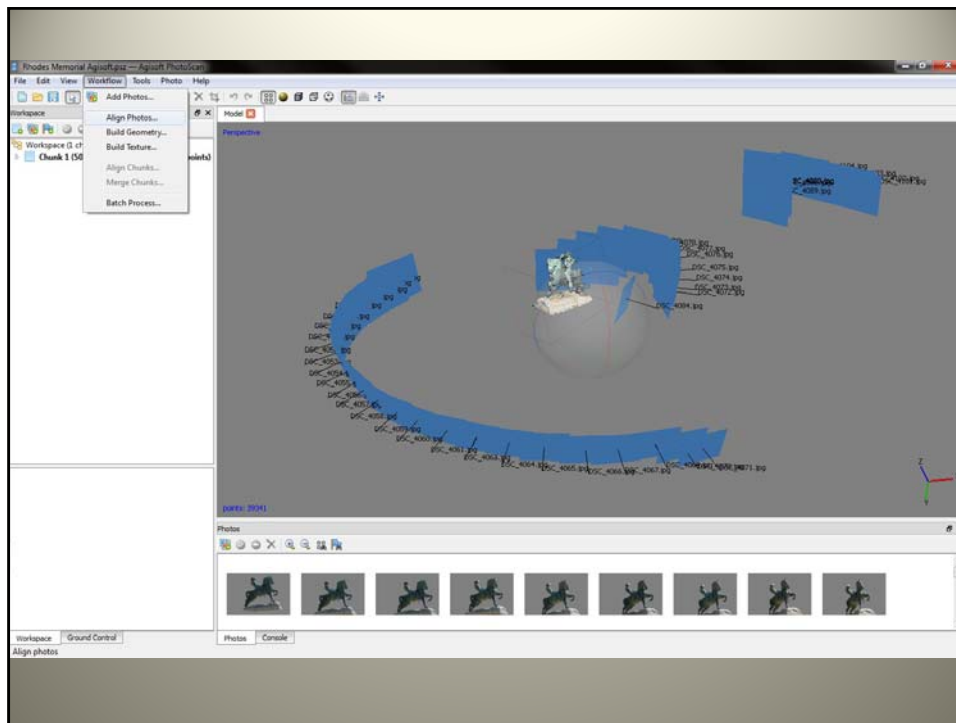
Full automation, the
tempting alternative

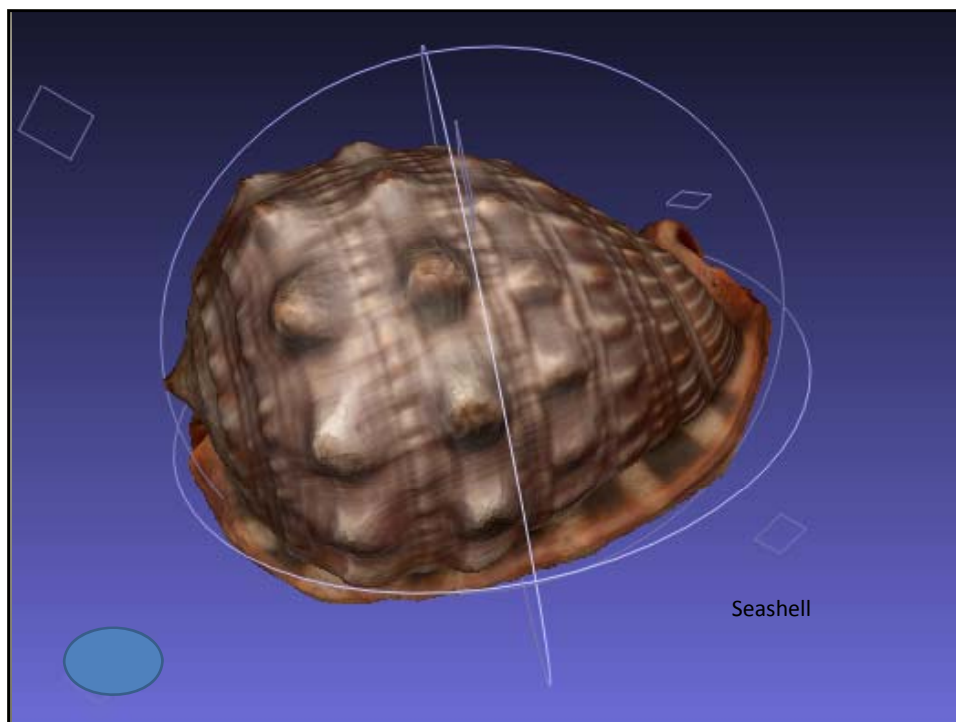
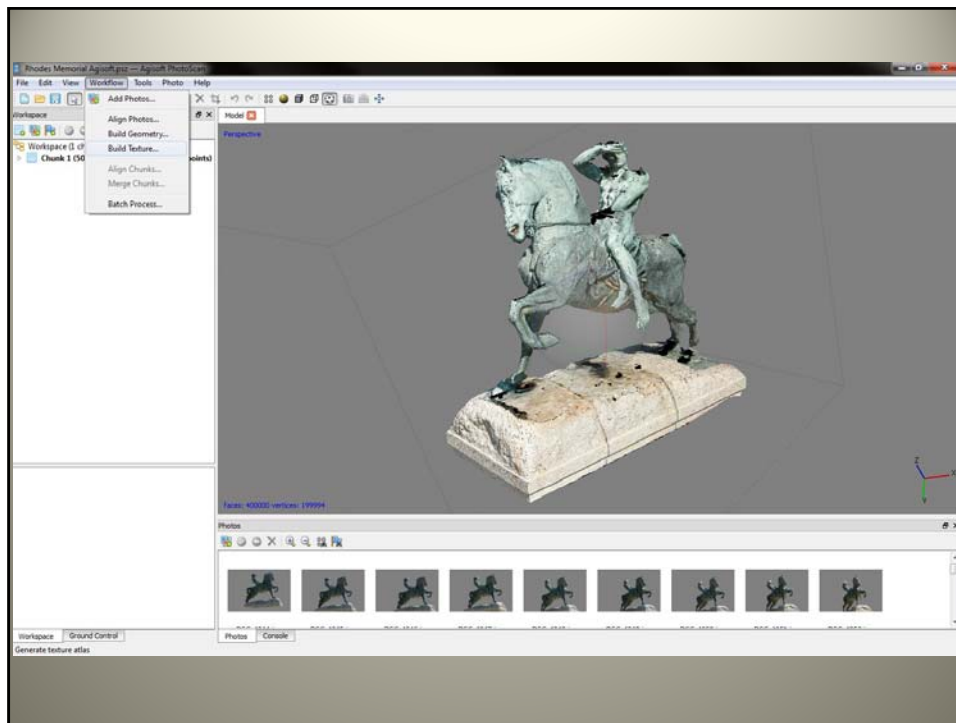


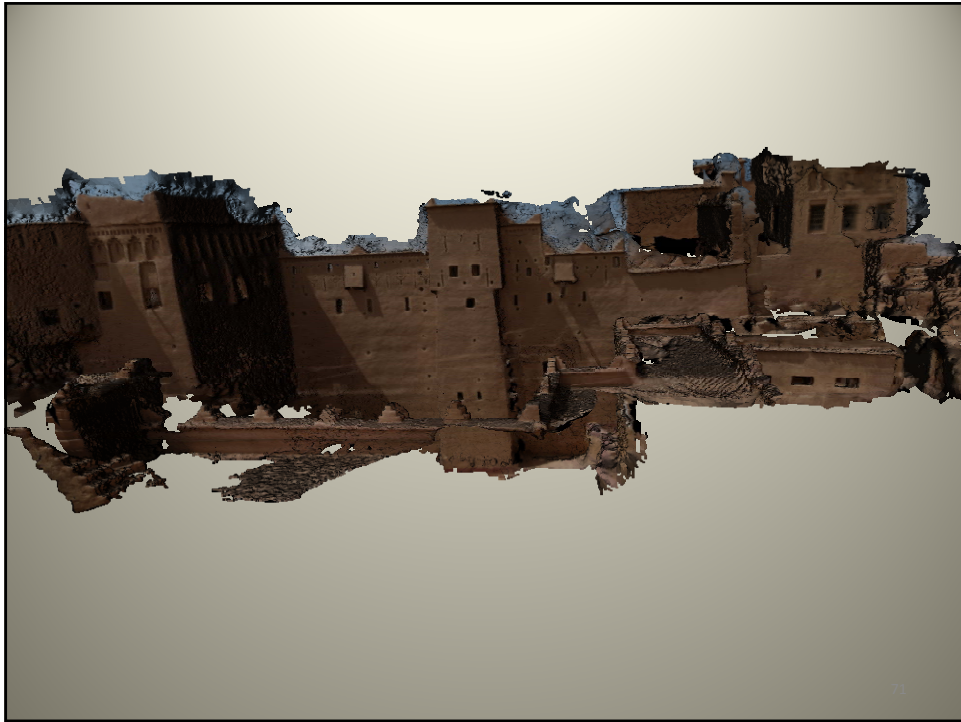
SFM

Workflow



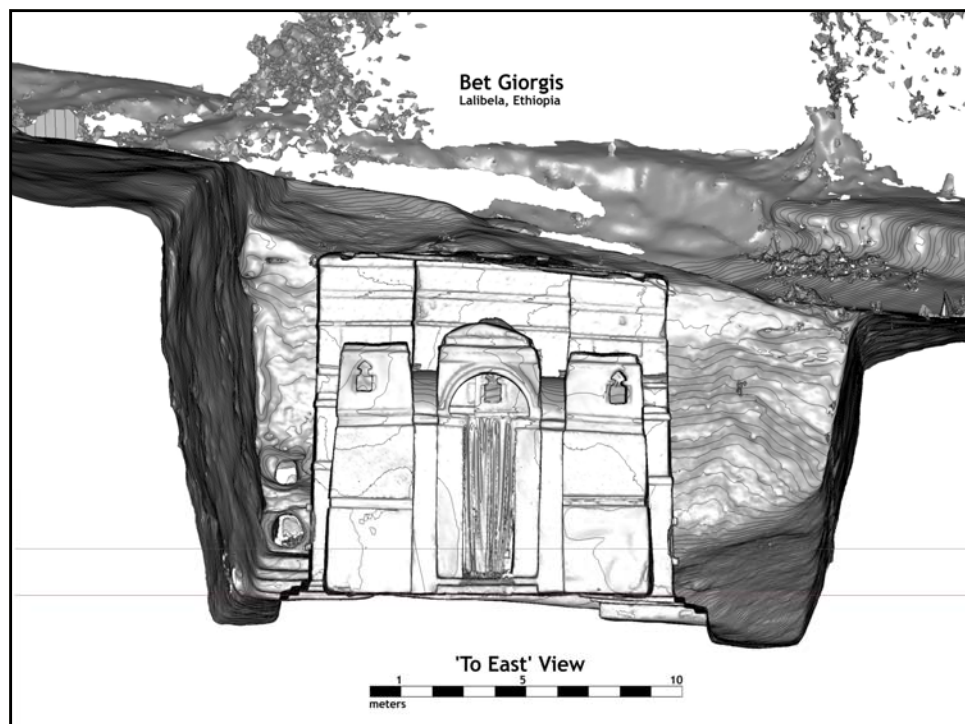
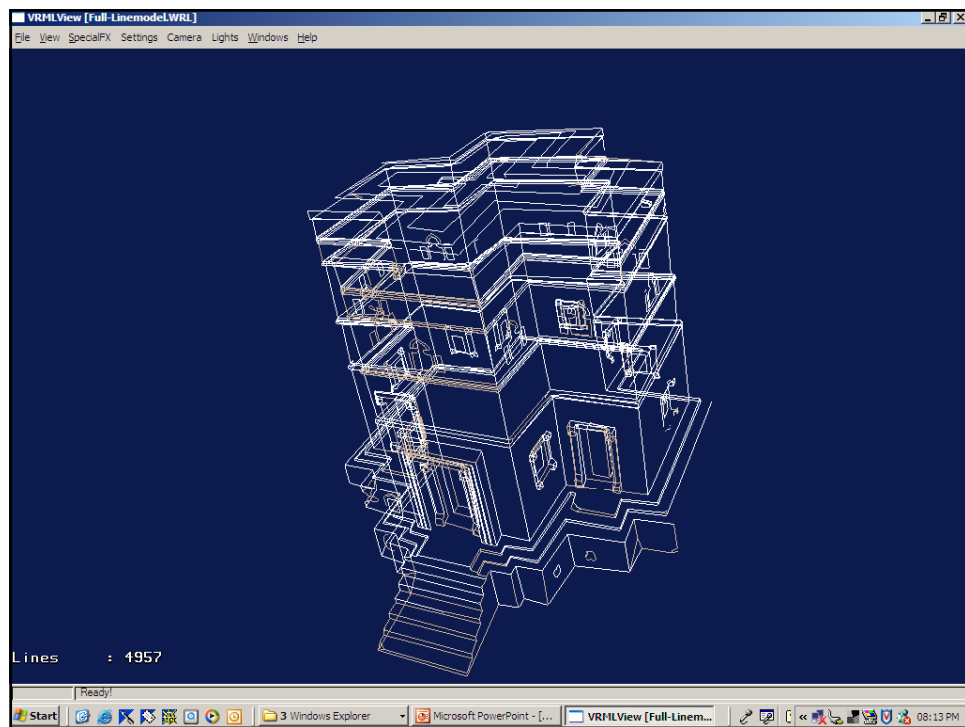


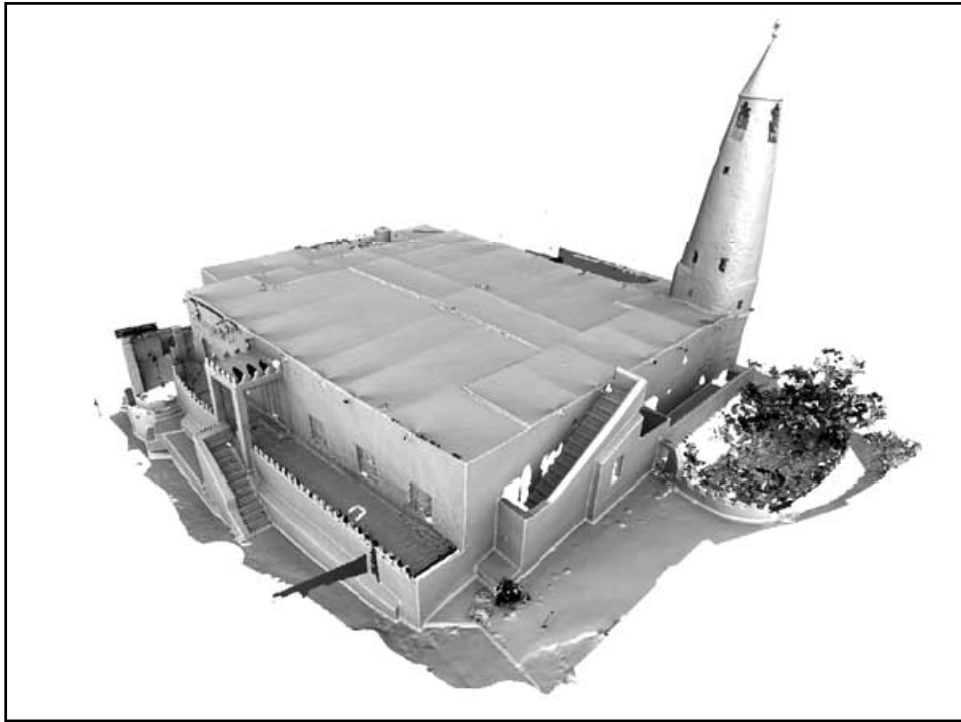




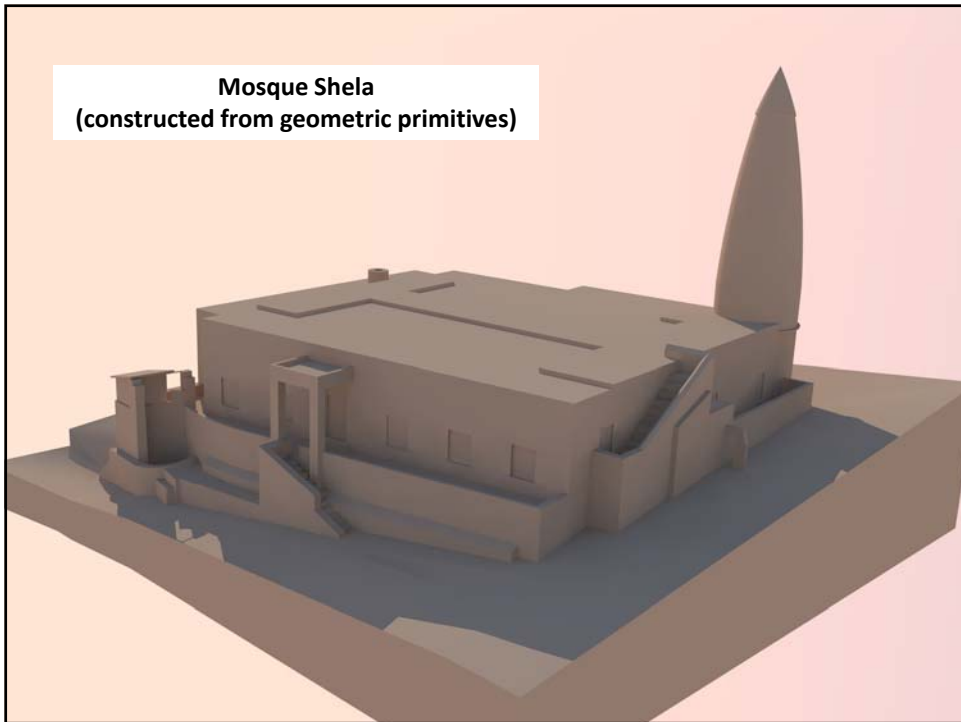
**End users are not always
ready for new
technologies**

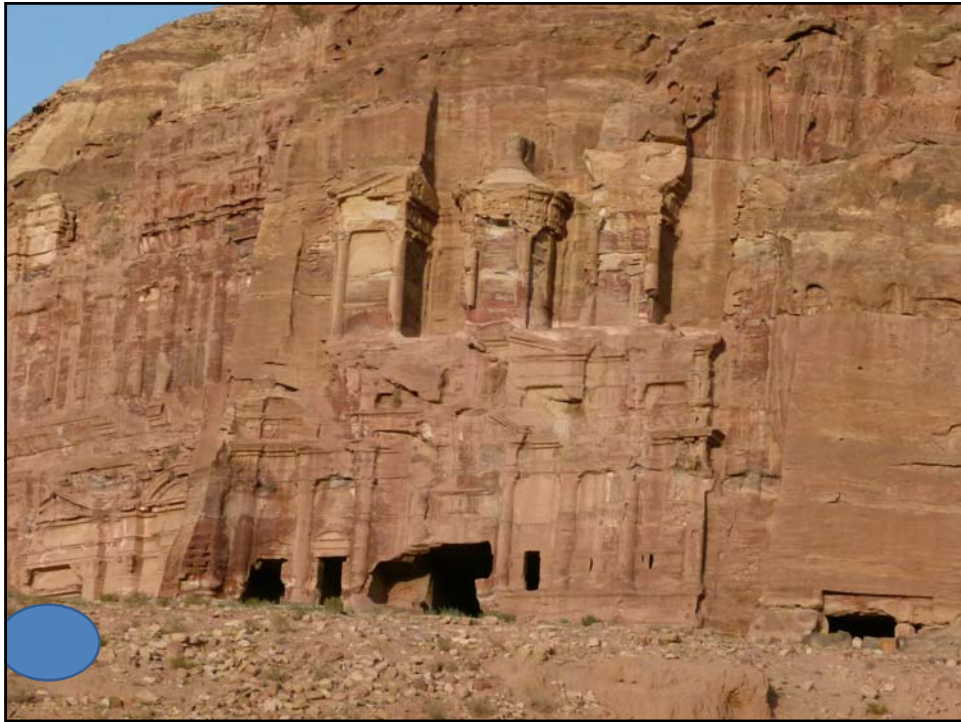




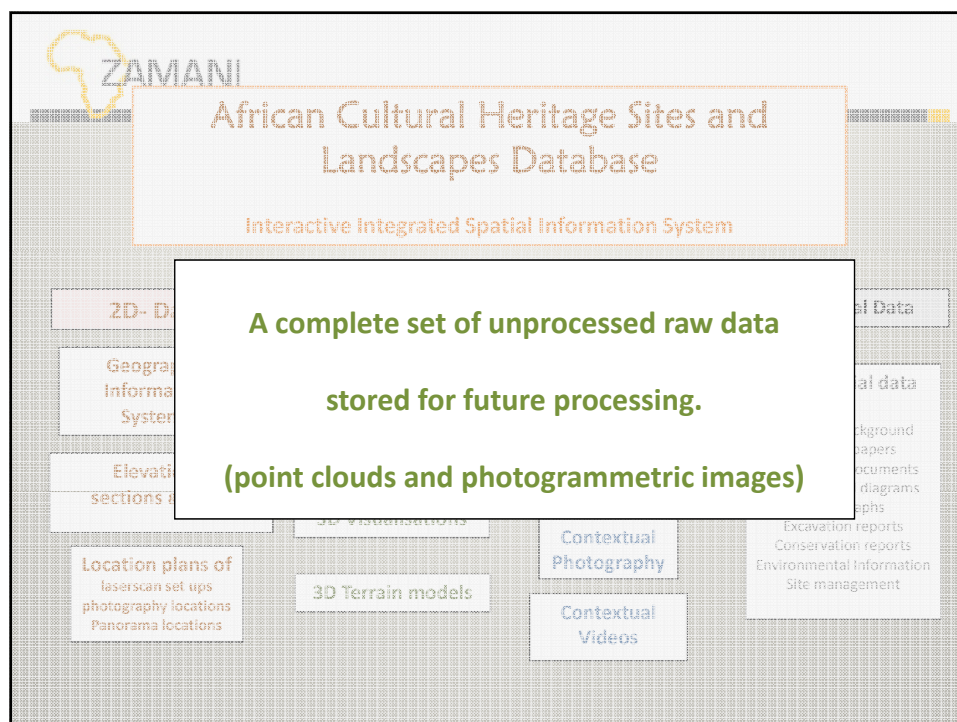
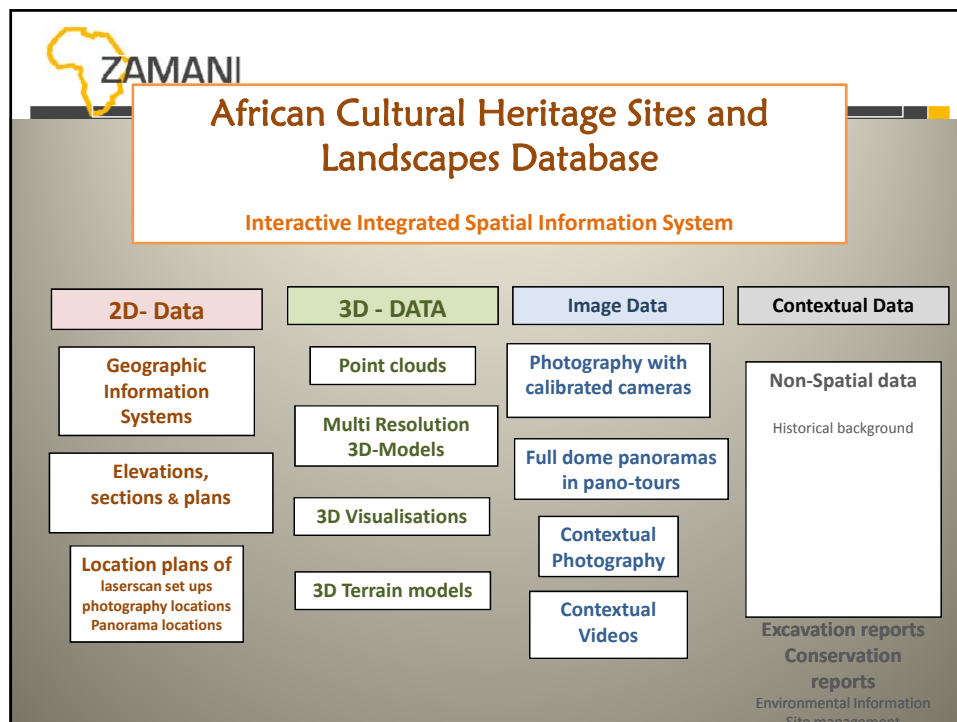


Mosque Shela
(constructed from geometric primitives)





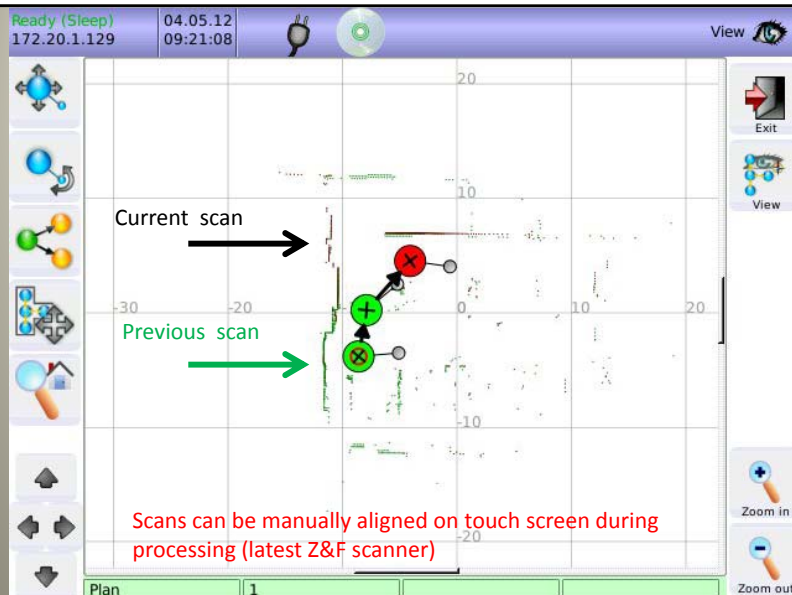
**Holistic approach to
documentation is
essential**



Evolution of laser scanner and data capturing

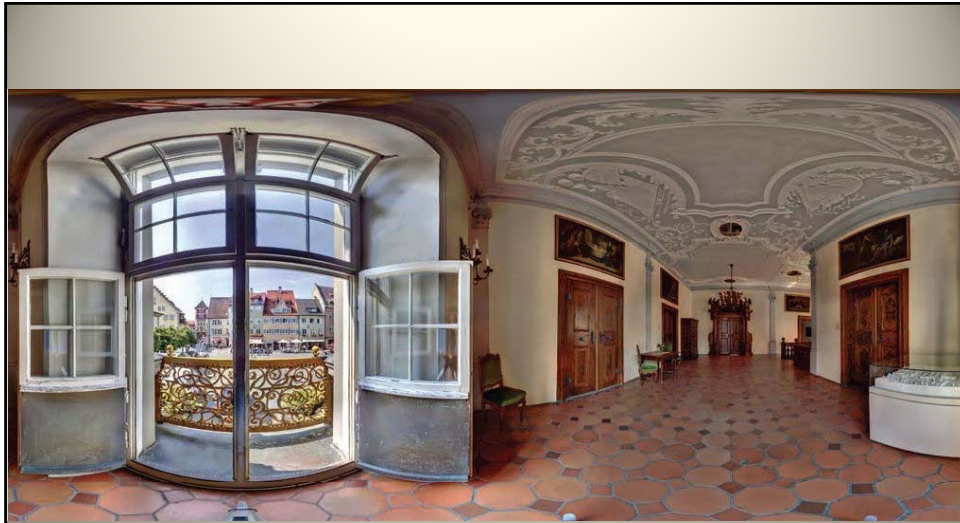
Year	No of scans / day	Principle of Measurement	Distance	batteries	In-built camera	Scan size (ptx)	Pre-registration	On-board control & storage
2005-2007	8 scans / day	TOF	up to 120 m for TOF scanner	external	no camera / low resolution	up to 300 MB	N/A	N/A
2008-2010	70 - 90 scans / day	Phase-based	up to 300 m for TOF scanner/ 80 m for Phase based	external & internal	no camera / low resolution	up to 500 MB	N/A	Yes
2011 - 2012	70 - 90 scans / day	phase-based / TOF	up to 190 for Phase based	internal	HDR capability (Z+F)	up to 4,000 MB	Yes	Yes

Site	No of points captured	Year
Kilwa fortress	< 50 Million	2003 - 2005
Elmina Fortress	300 Million	2006
Lalibela churches	6.6 Billion	2005-2008
Sudan	3 Billion	2009
Mozambique Fortress	7.4 Billion	2009
Songo Mnara	6 Billion	2010-2011
Petra	> 6 Billion	2011-2012



Approximate real-time (on-site) registration

Instrument display

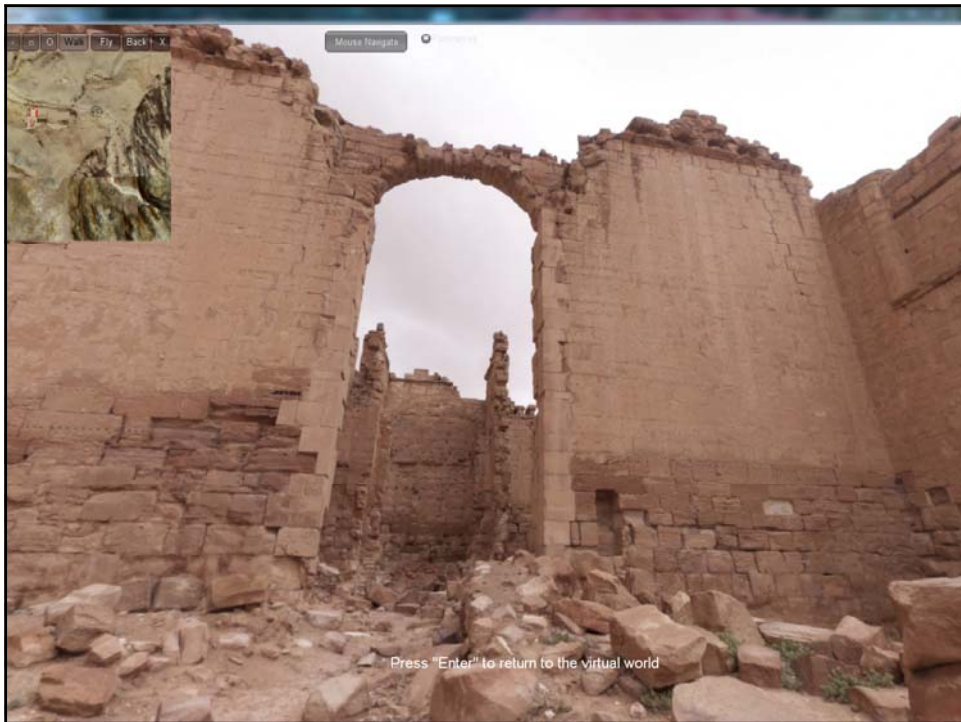


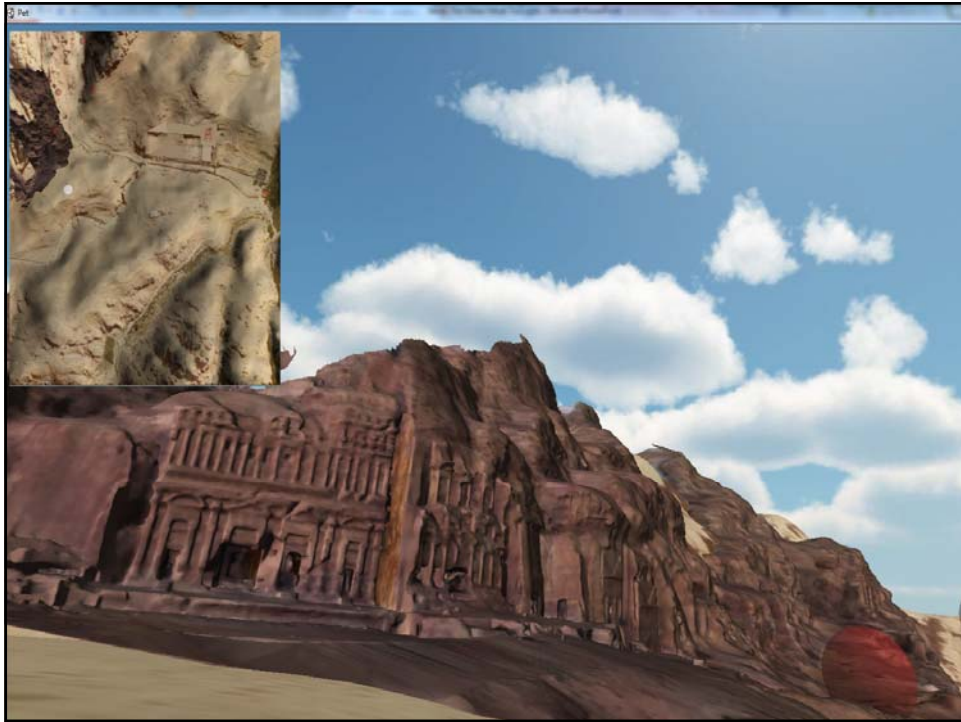
**Fully automated build-in HDR (High Dynamic Range)
photography**



Panorama Tour versus Virtual Tour







Unmanned Aerial Vehicles UAVs



- quadcopter

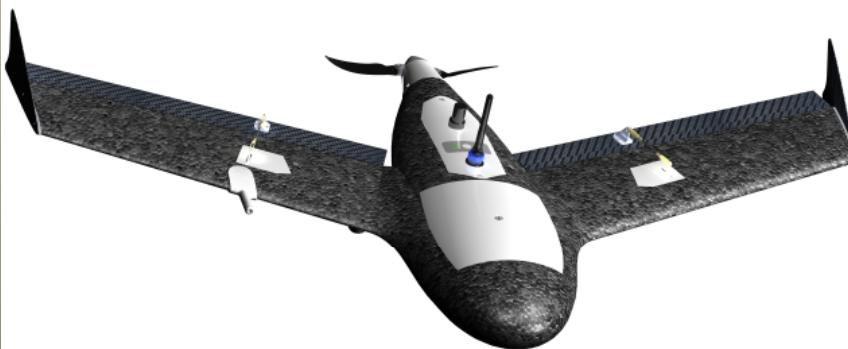


- hexacopter



- octocopter

Fixed Wing UAVs





Gateway X100

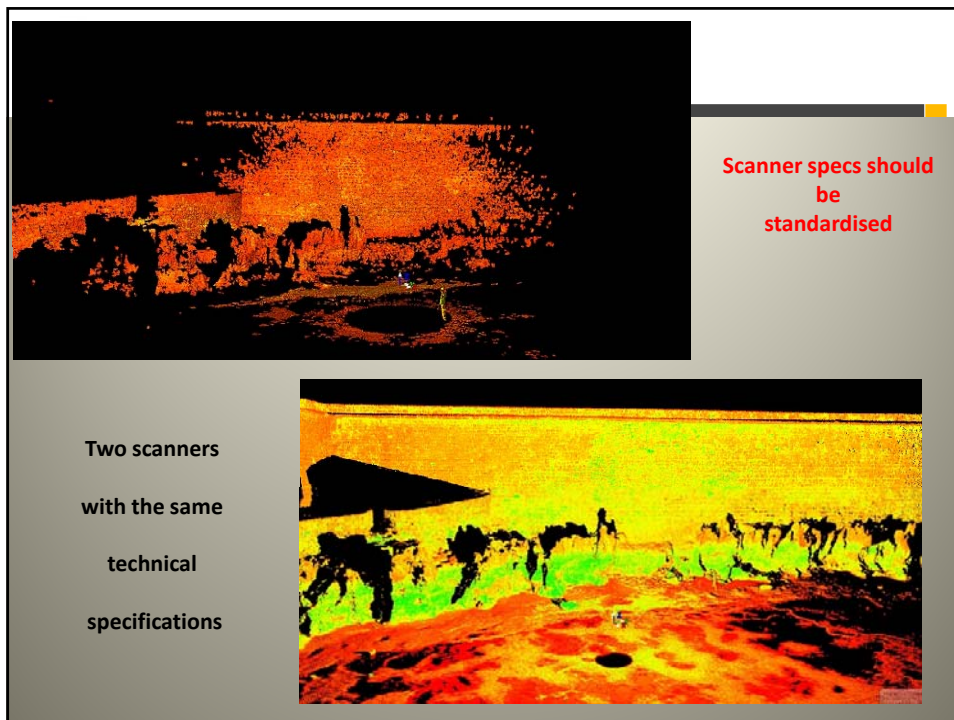
Navigation:

Pre-programmed or manual control from ground

- Automatic take-off & landing
- Fully automated programmable flight
- Waypoint navigation
- Autonomous camera triggering
- Fail-safe routines
- Range 50 km /45 min



Standards in Documentation



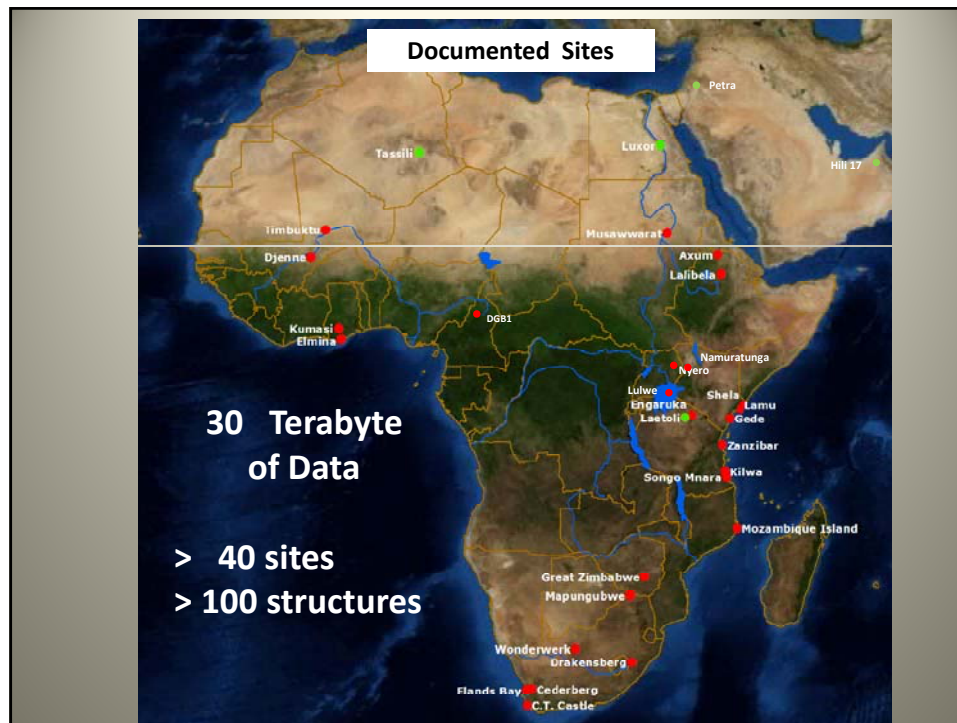
Guidelines or Standards for laser scanning are highly desirable

- Equipment (technical specs)
- Data acquisition (measures of quality – as in surveying)
- Standard for end product (modelling ,texturing)
- Metadata (differentiated by application area. E.g. rock art, buildings, cultural landscape)

Some of the major challenges

- Large amounts of data generated not used to full potential
- Subjective (cosmetic) augmentation of data, Appearance favoured over faithful representation
- Lack of quality control (poor-quality, nice-looking 3D models are produced)
- Lack of industry standards
- Laser scanning is often incorrectly seen as the solution to all documentation projects (data integration)



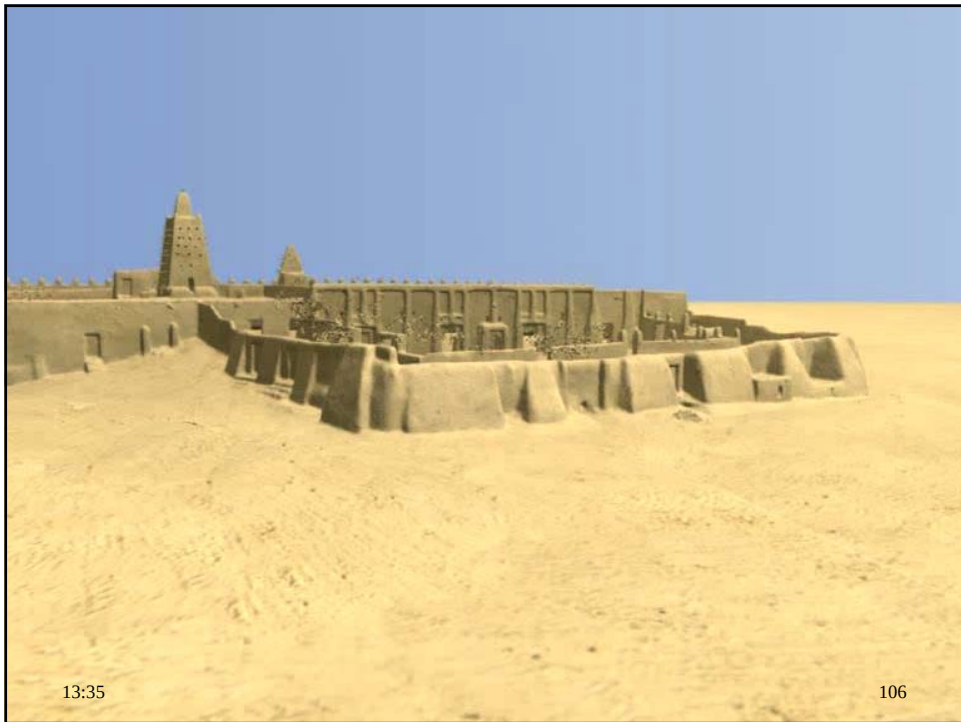


Timbuktu

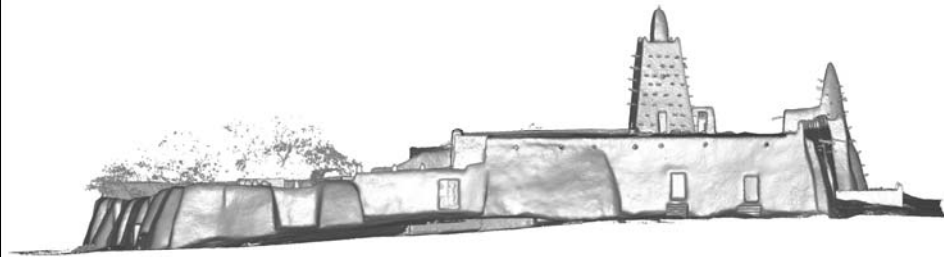
Djenne

Djinguereber Mosque in Timbuktu , 14th Century





Djingereyber Mosque
Timbuktu, Mali

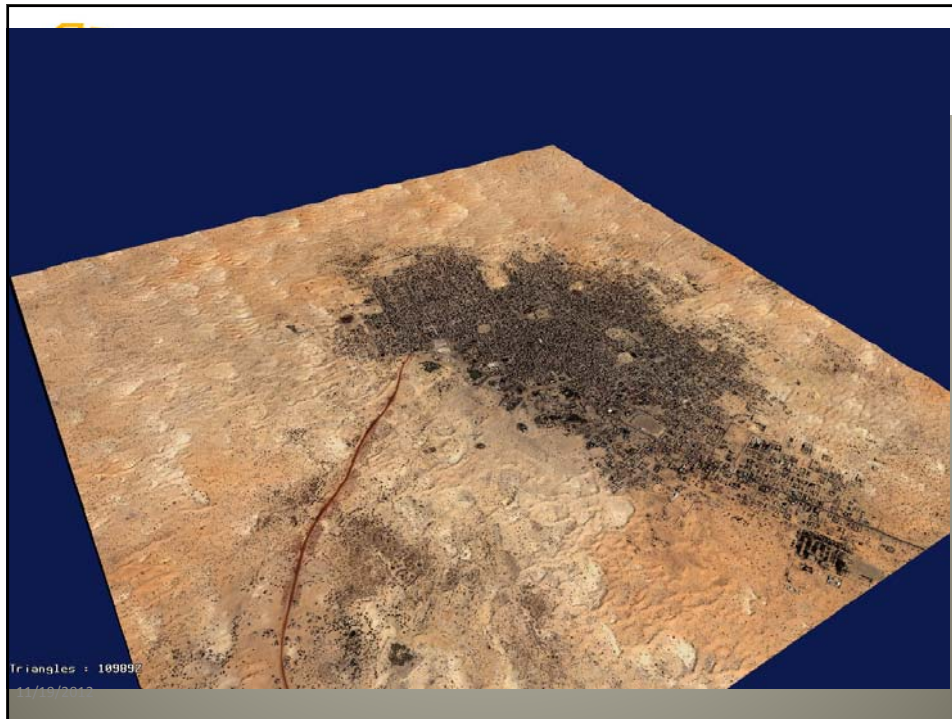


South View

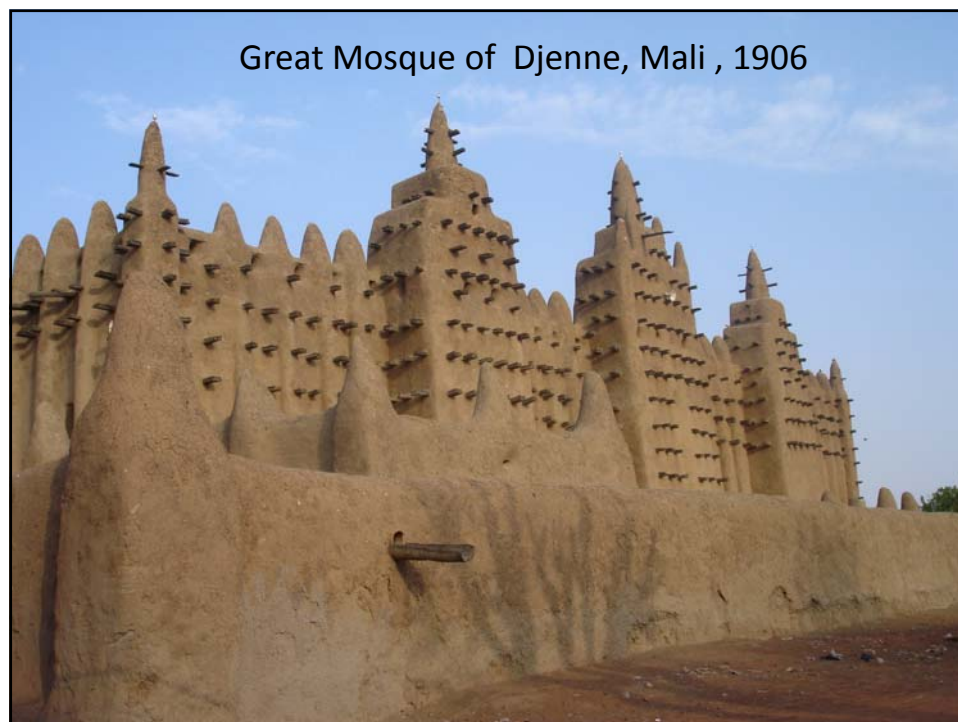
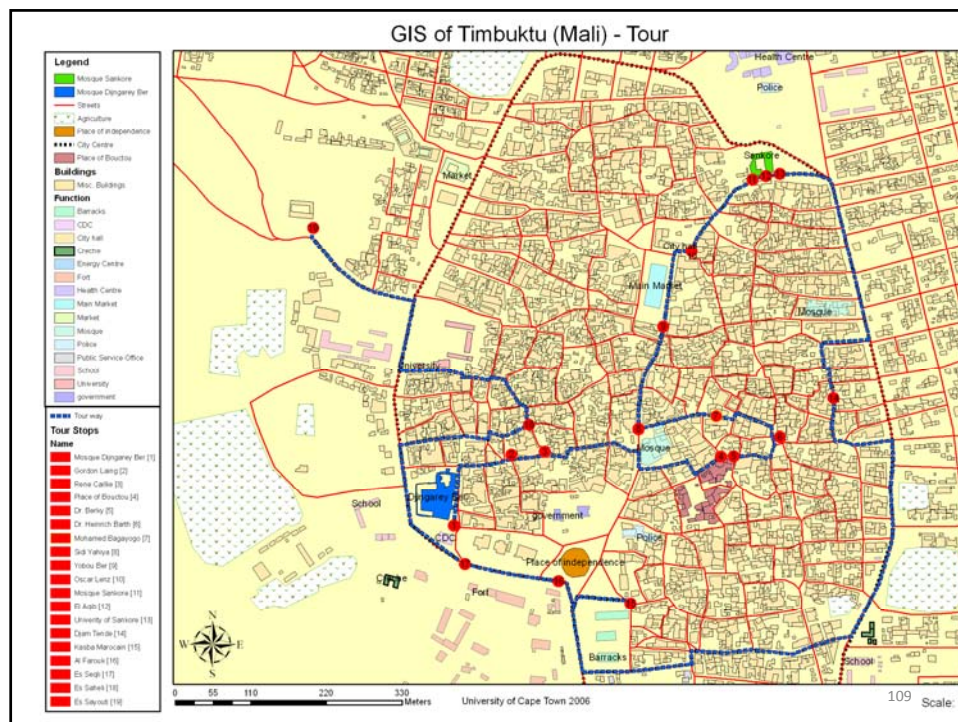


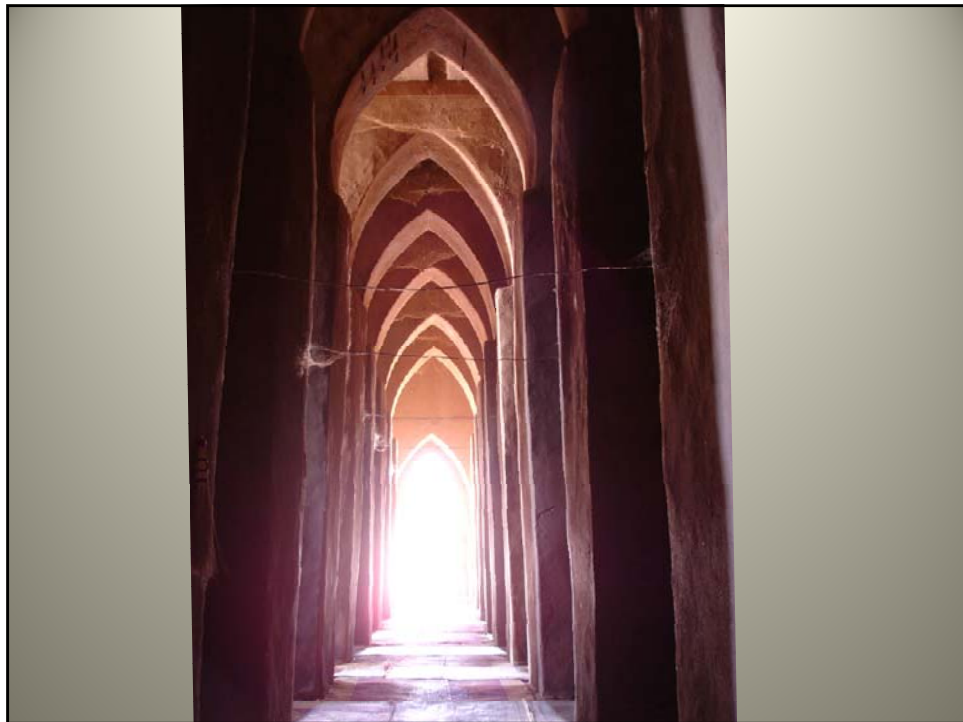
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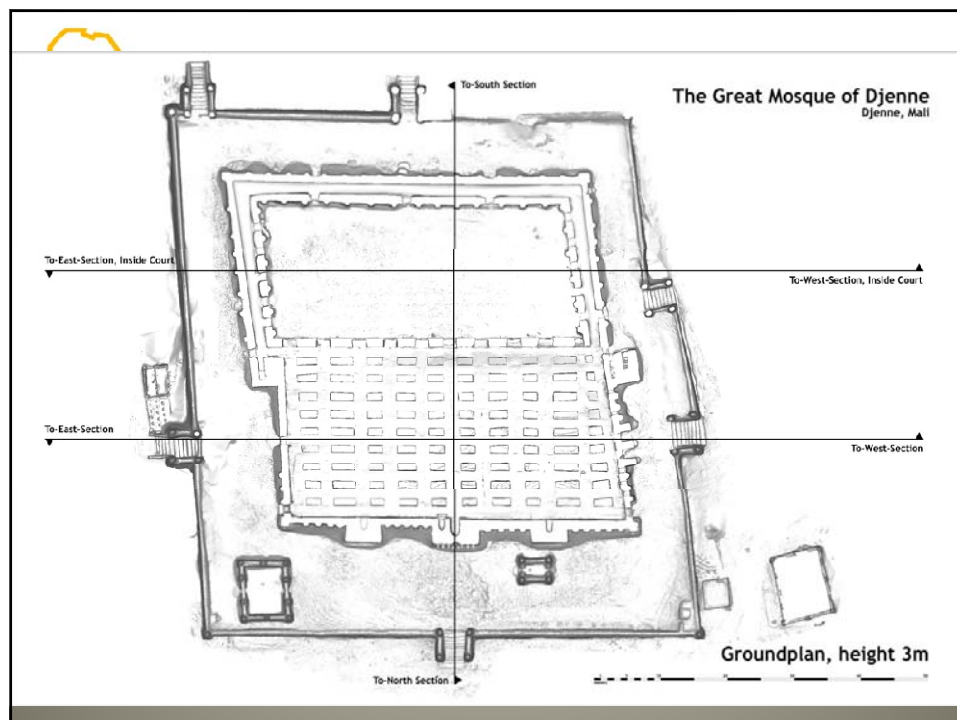
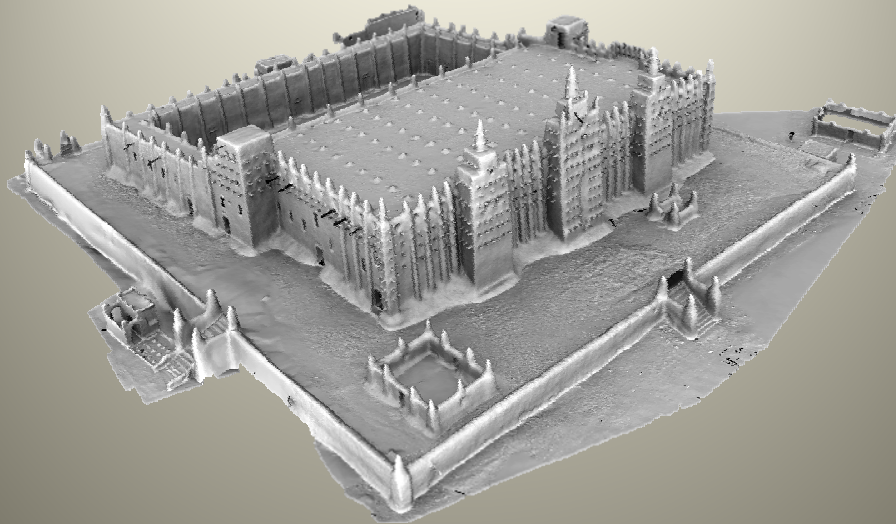


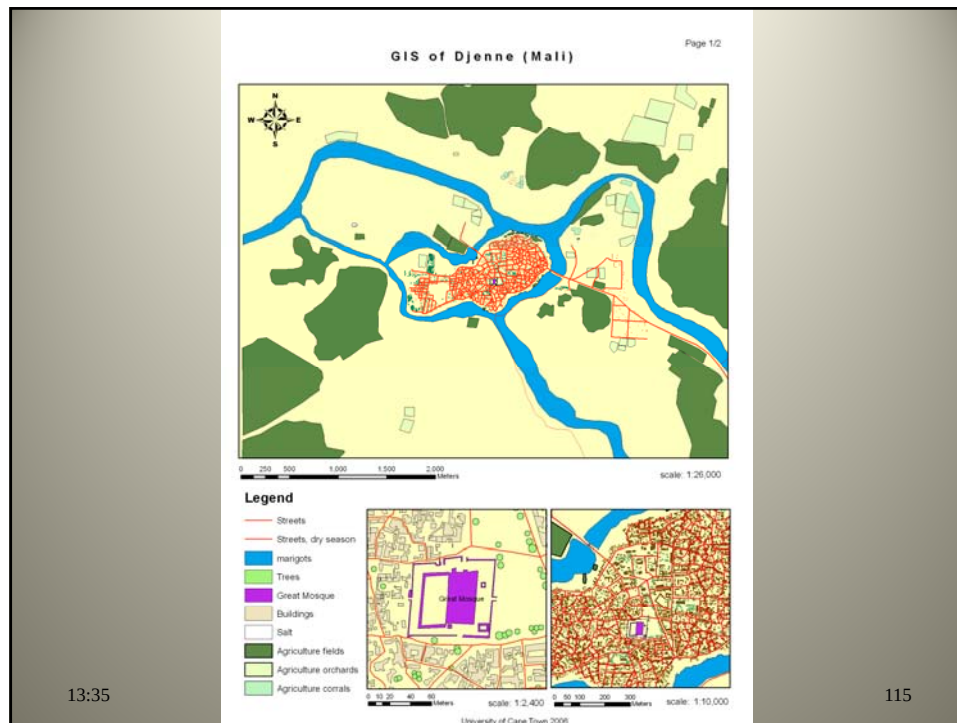
Triangles : 109092
11/08/2012





Djenné – 3D Model





13:35

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Mocambique Island

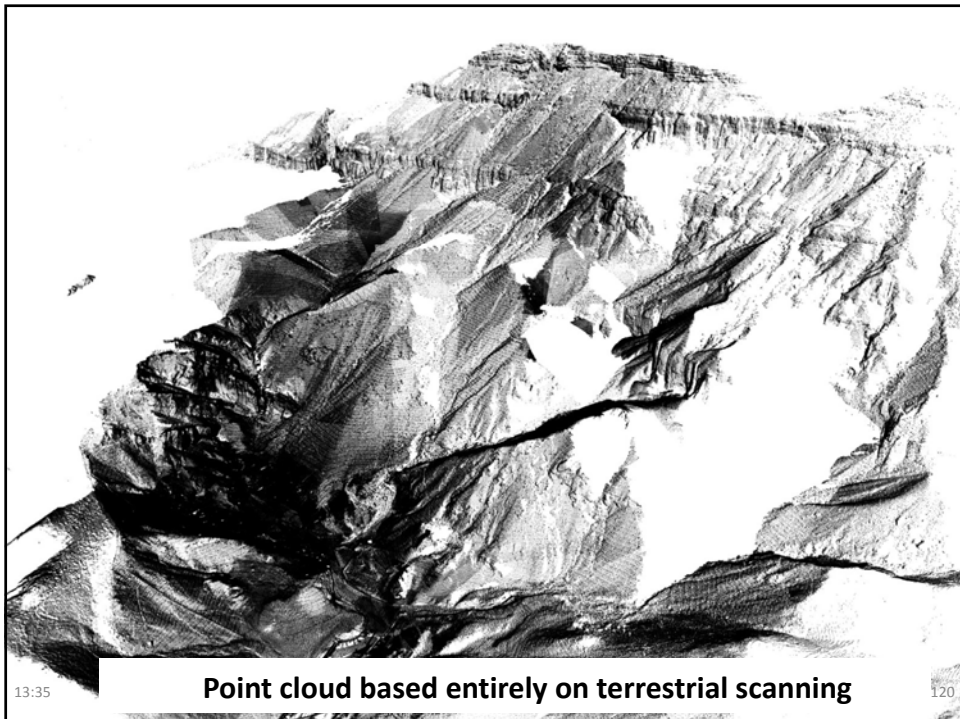
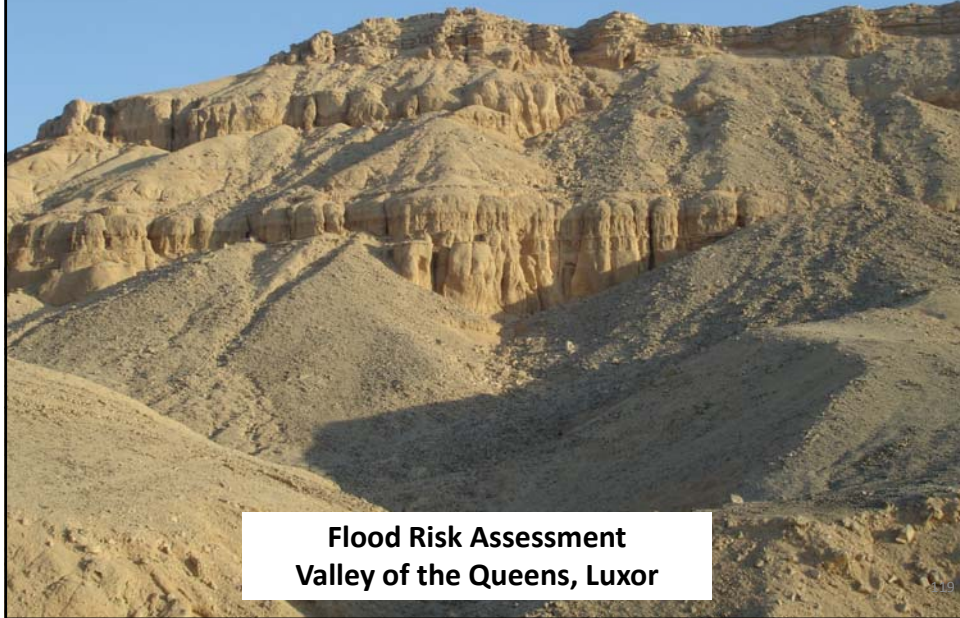
St Sebastian Fortress

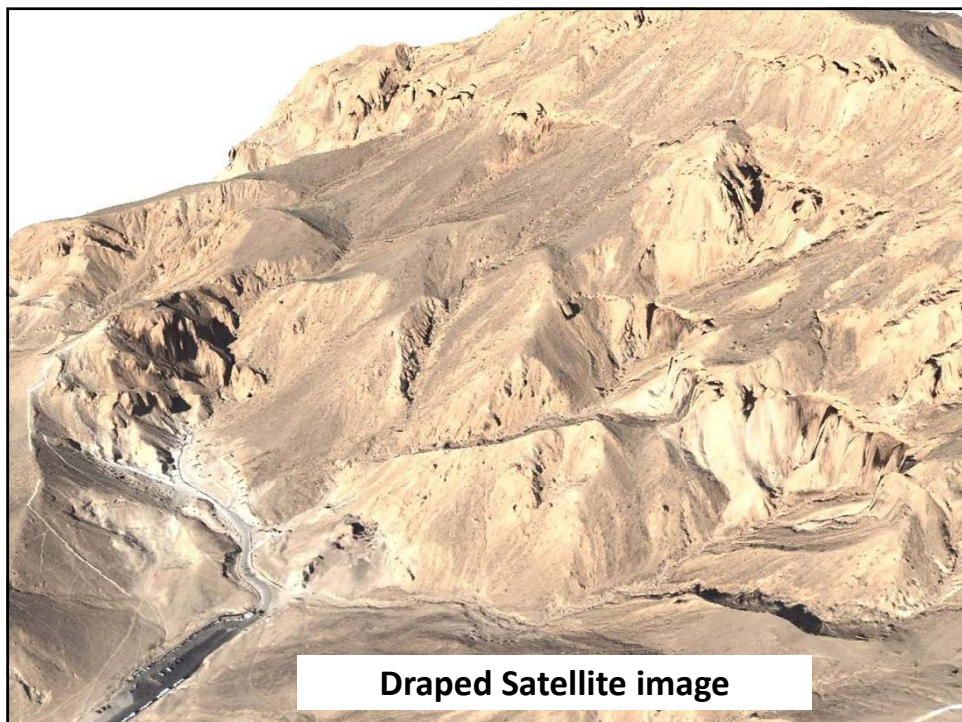
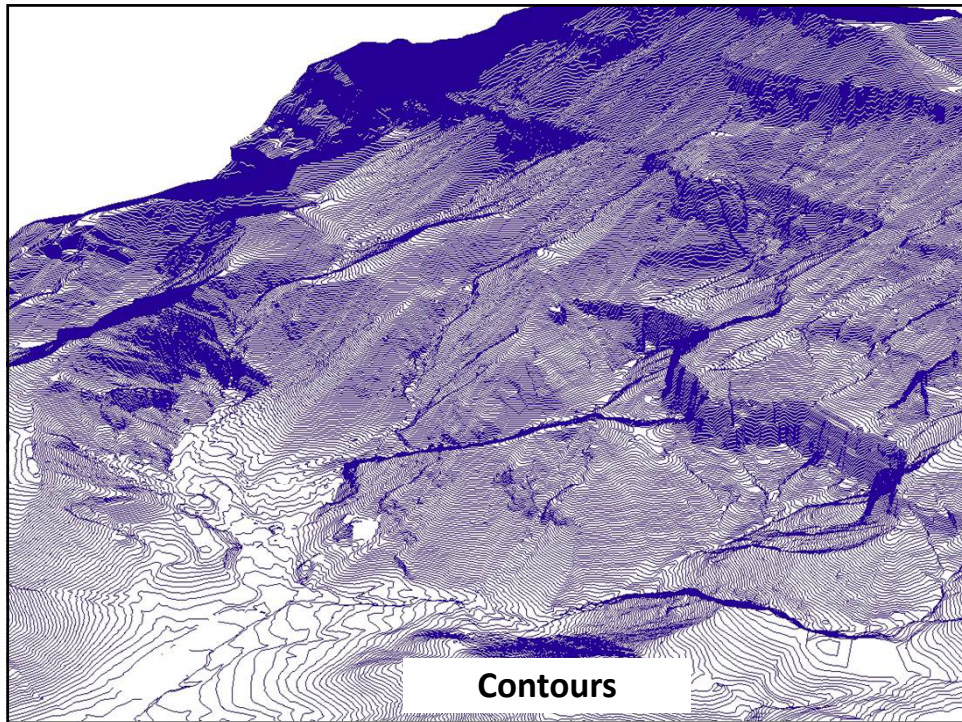
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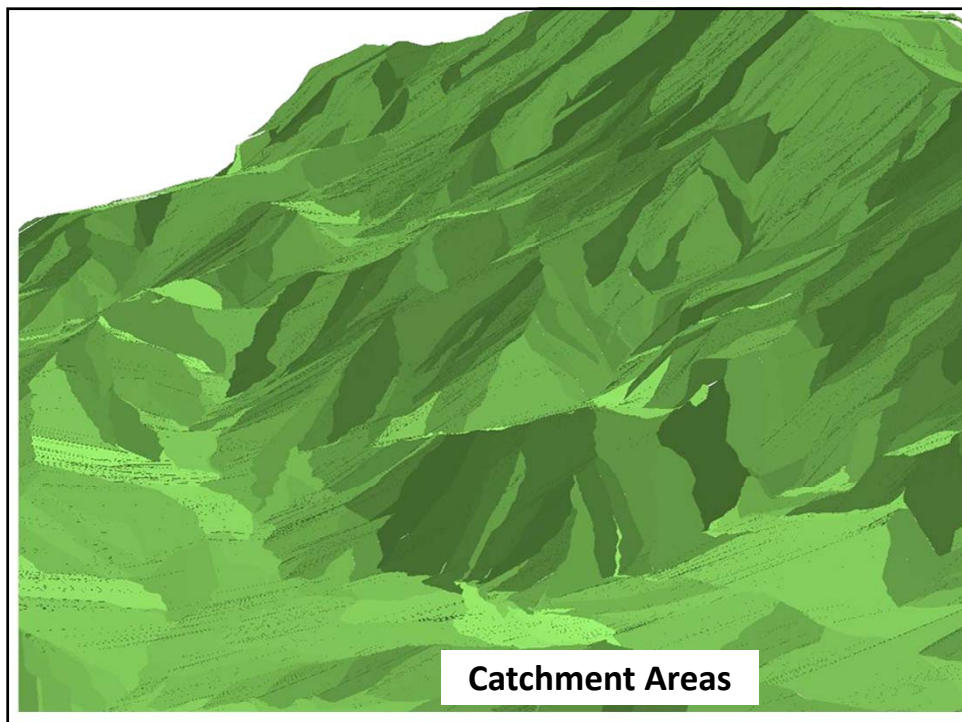
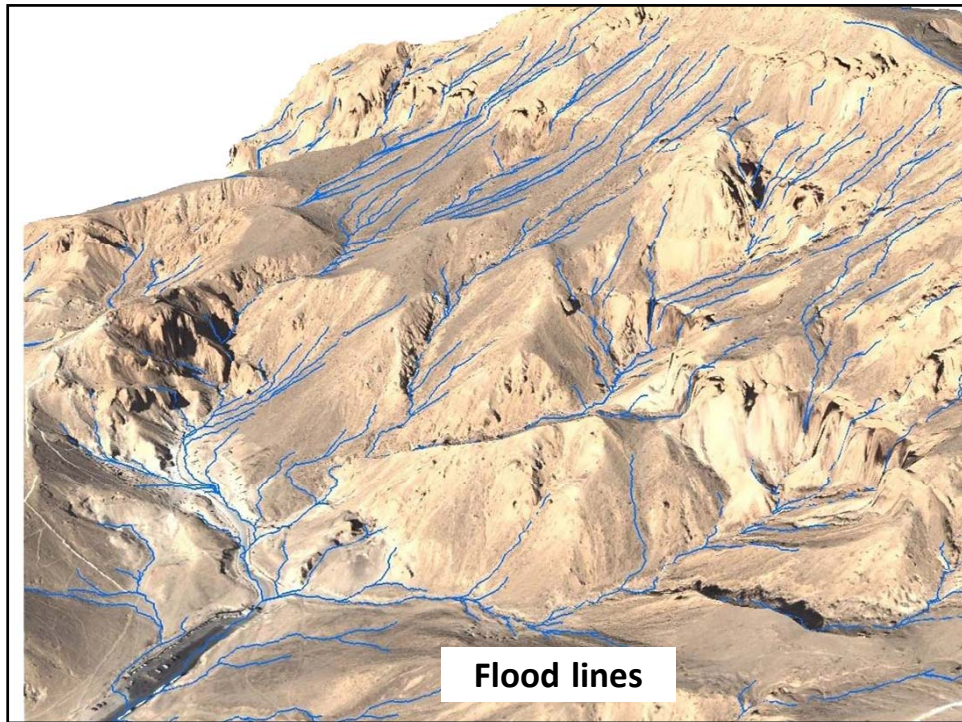
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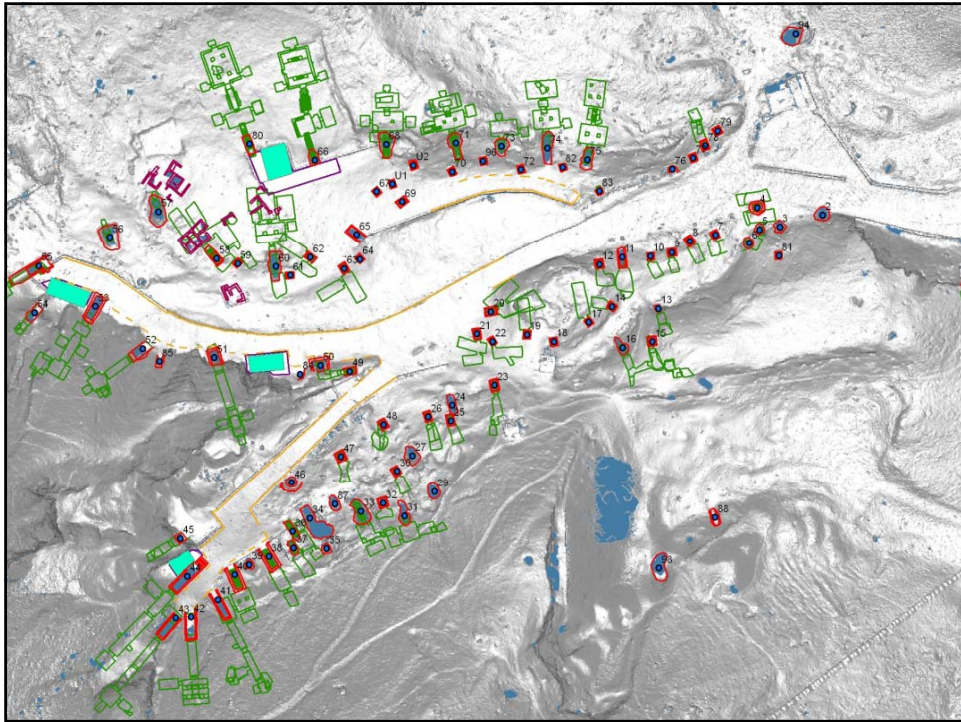
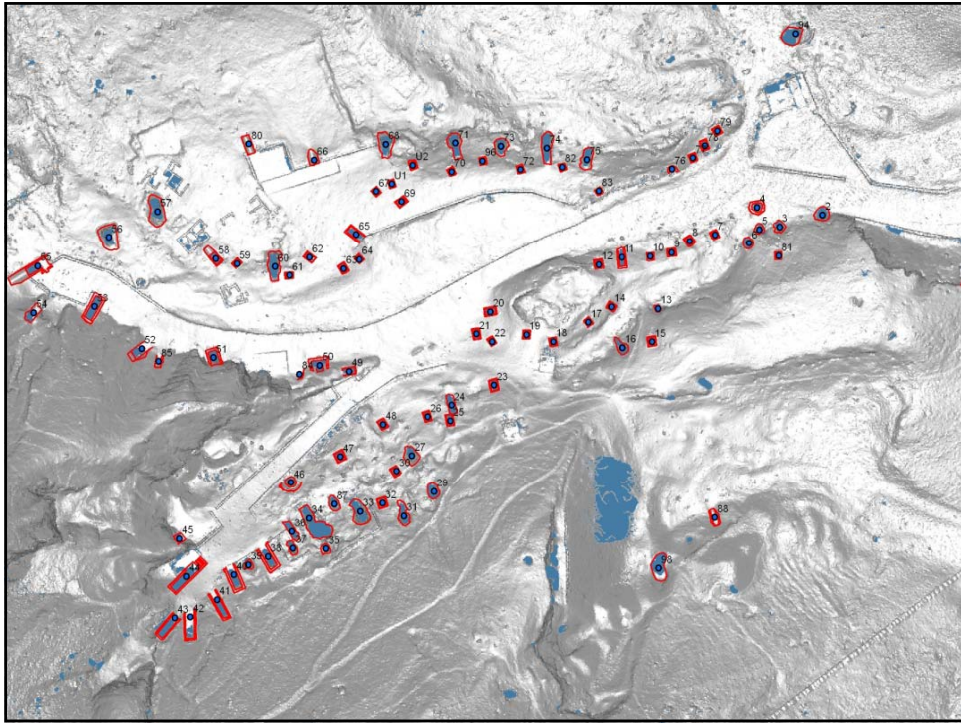


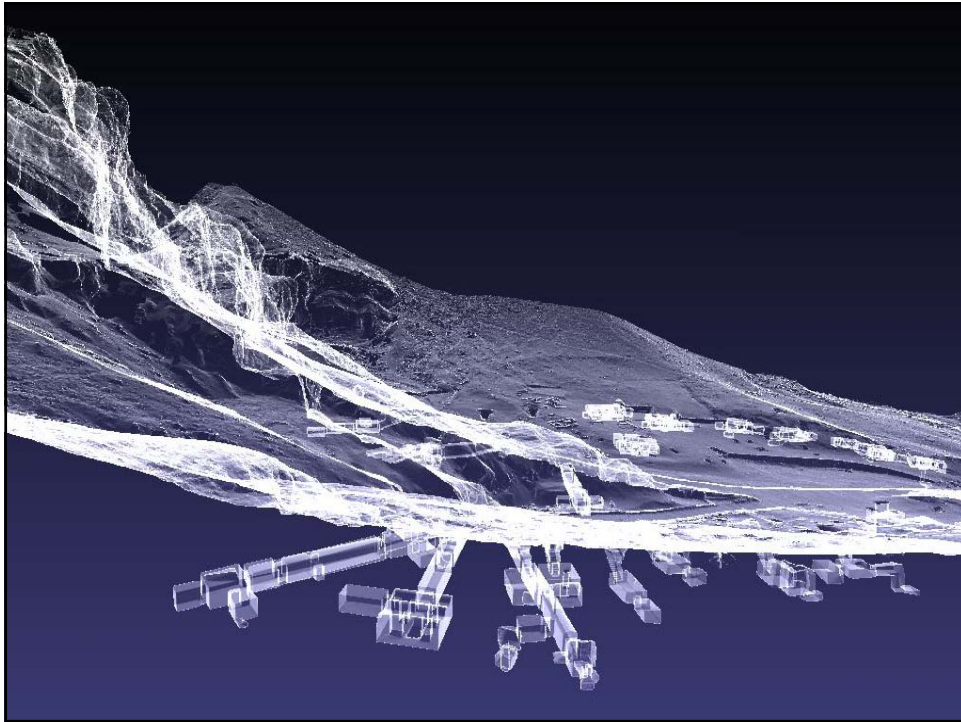
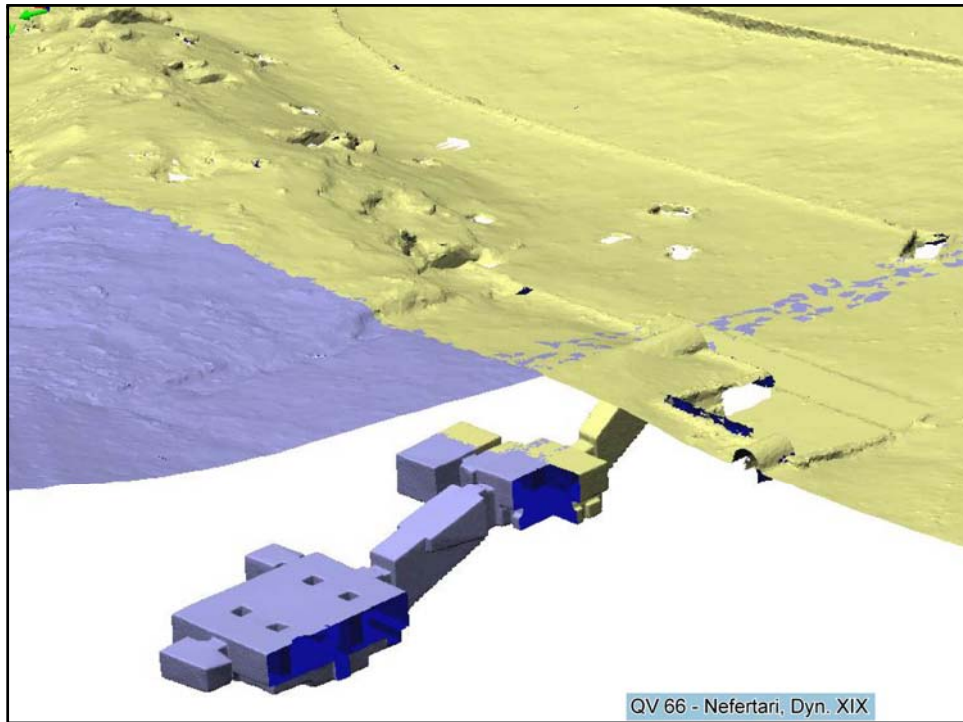
The Valley of the Queens, Luxor – Egypt











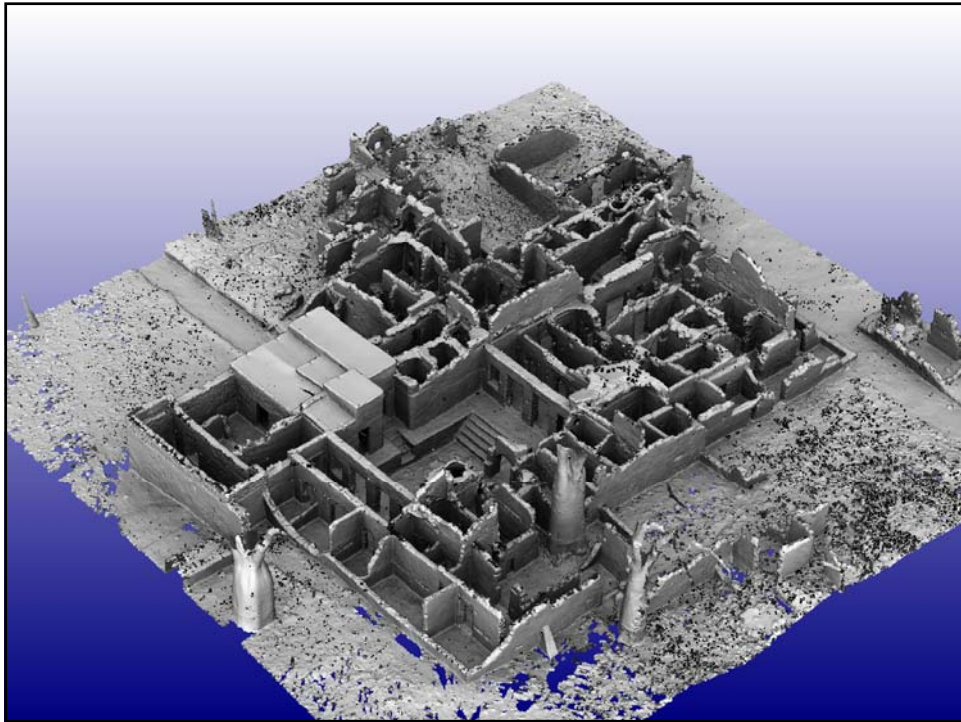
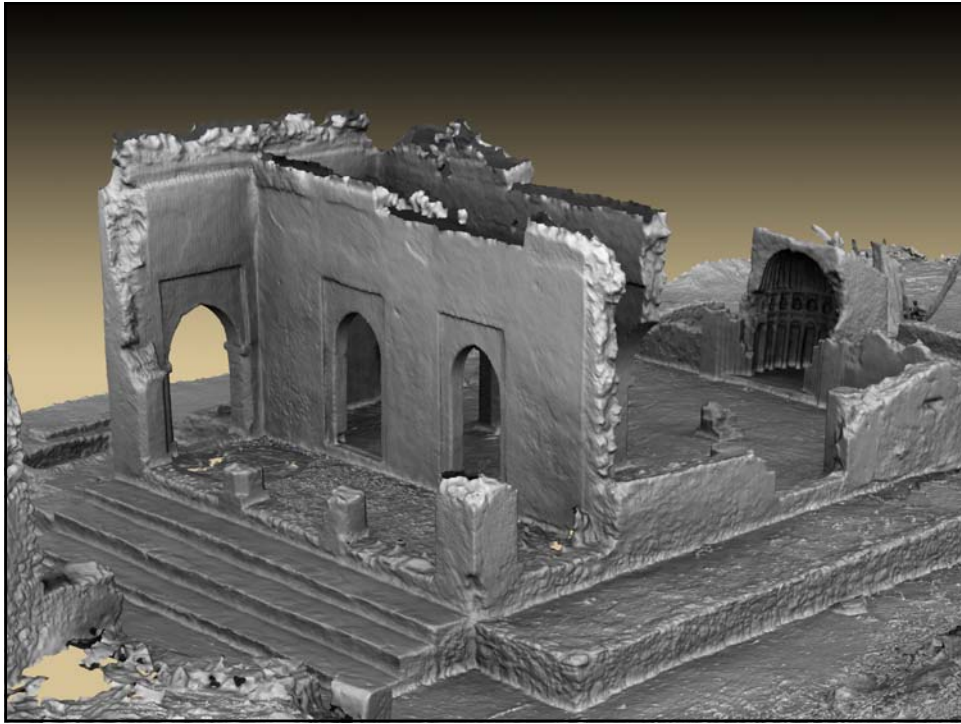
Tanzania

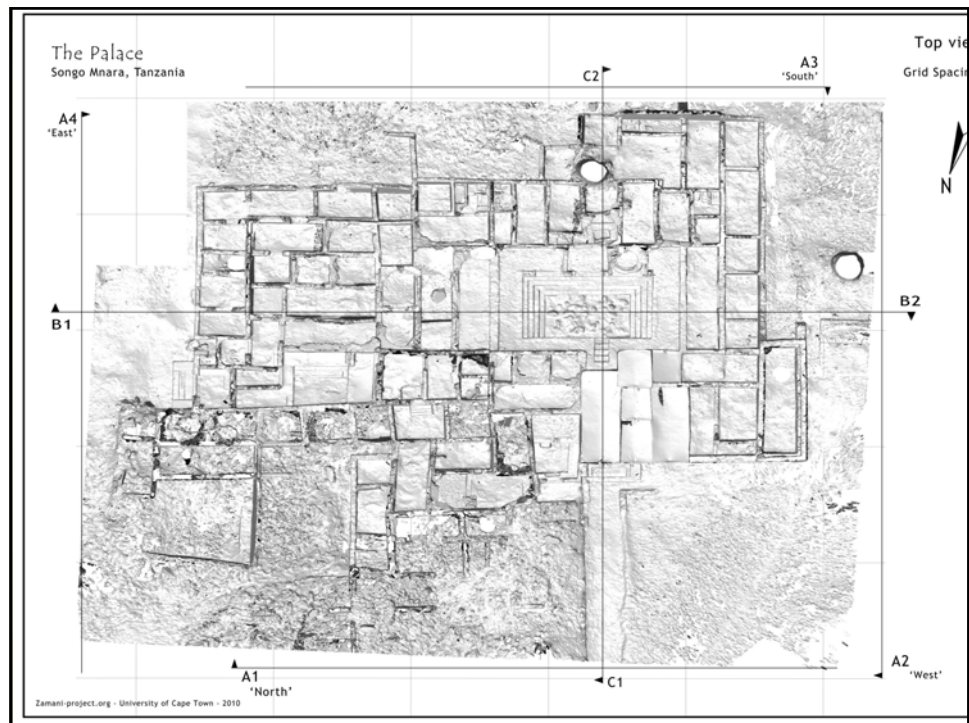
Songo Mnara

13:35

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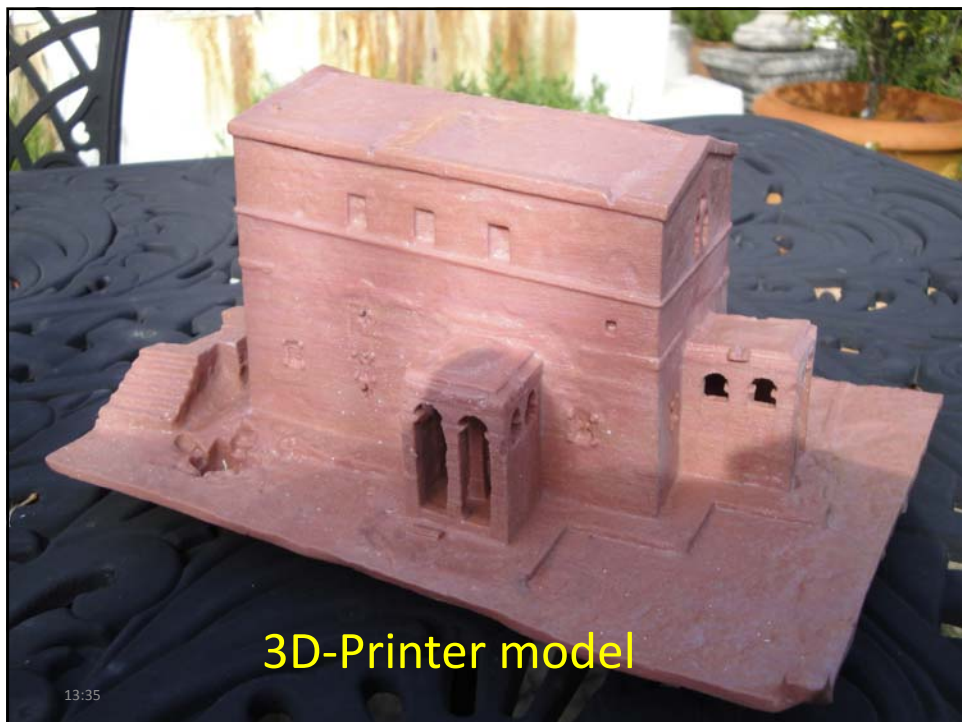
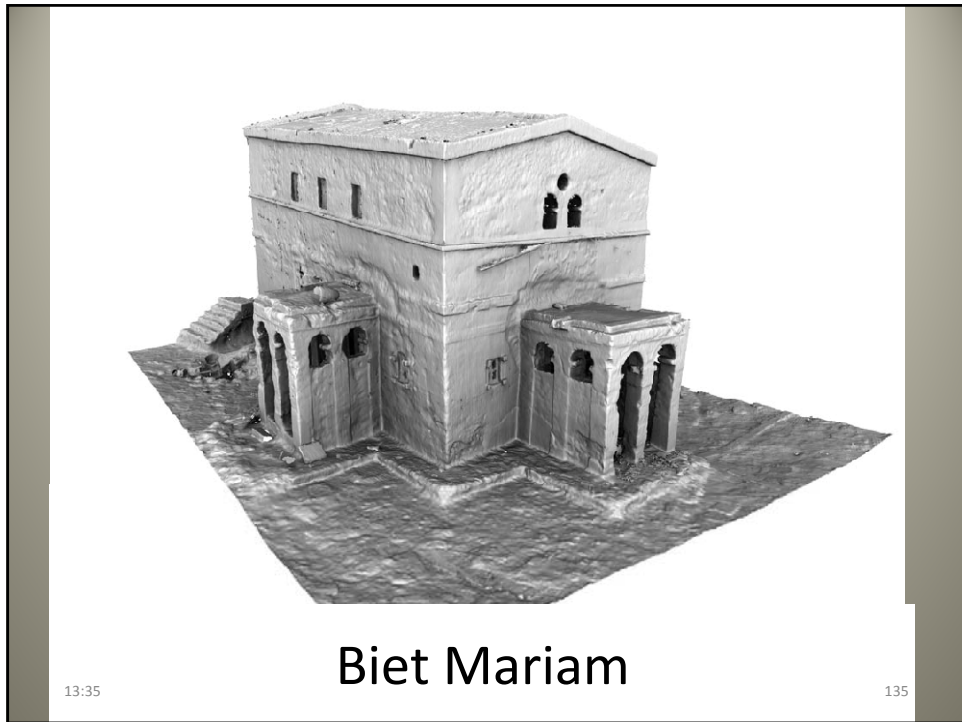






Ethiopia

Lalibela

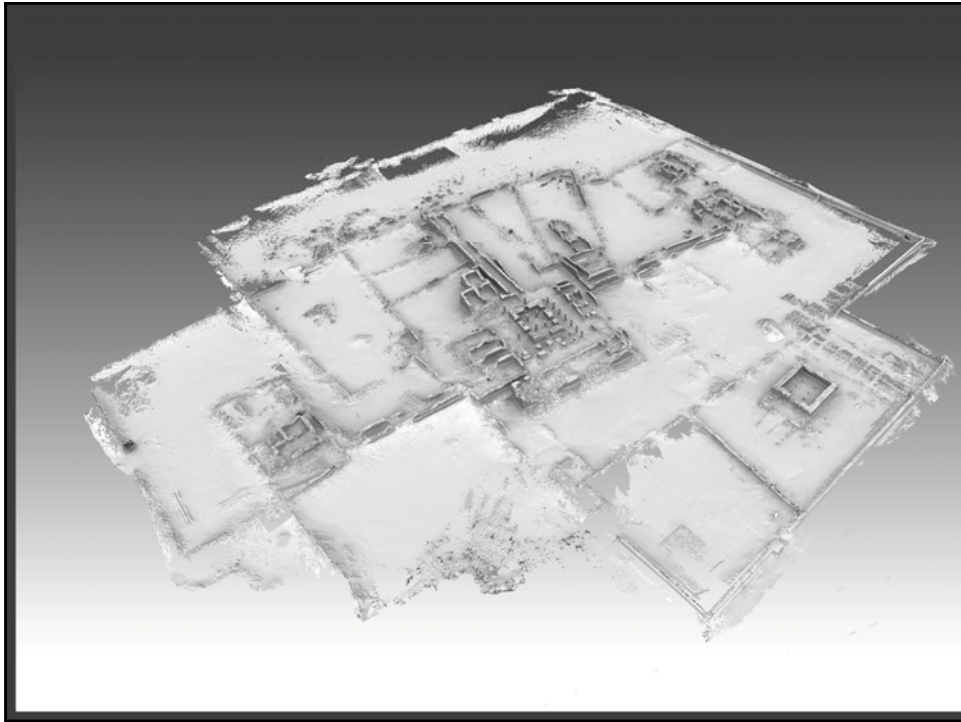


Sudan

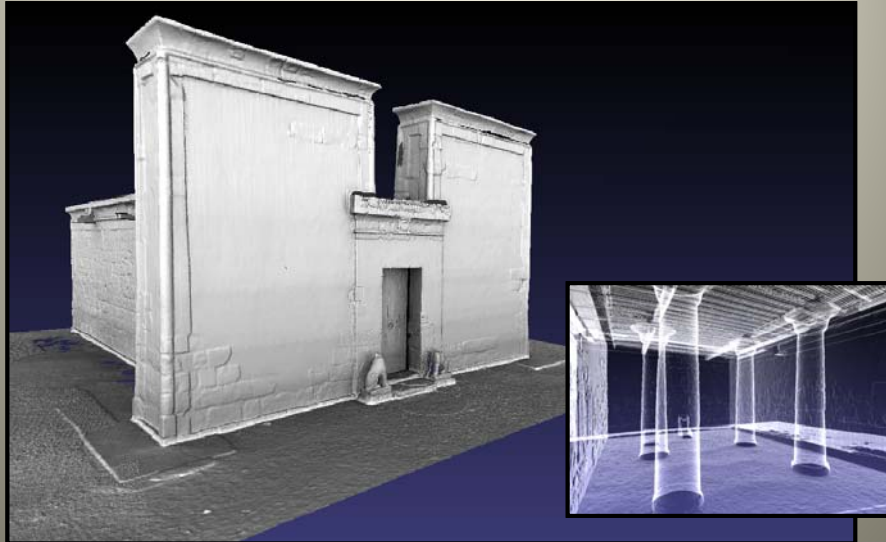
Musawwarat es Sufra



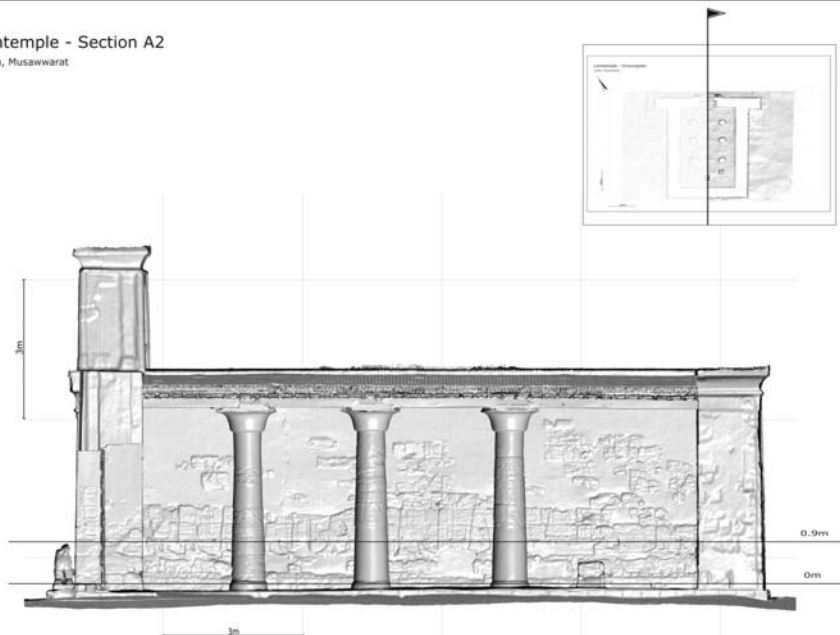
Musawwarat es-Sufra, Sudan, 3rd century BC



3D Model



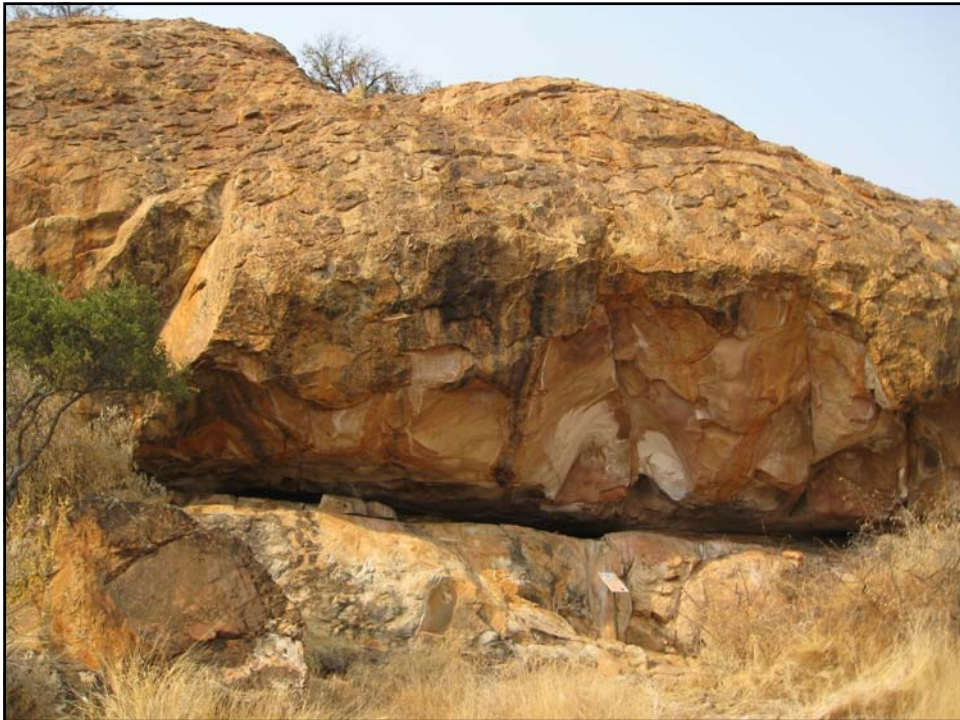
Liontemple - Section A2
Sudan, Musawwarat



South Africa

Rock Art

143





Zimbabwe

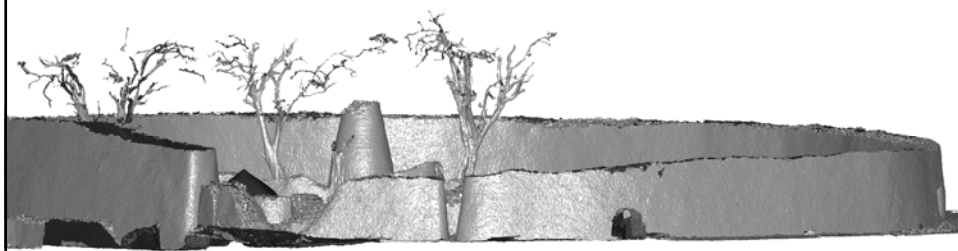
Great Zimbabwe

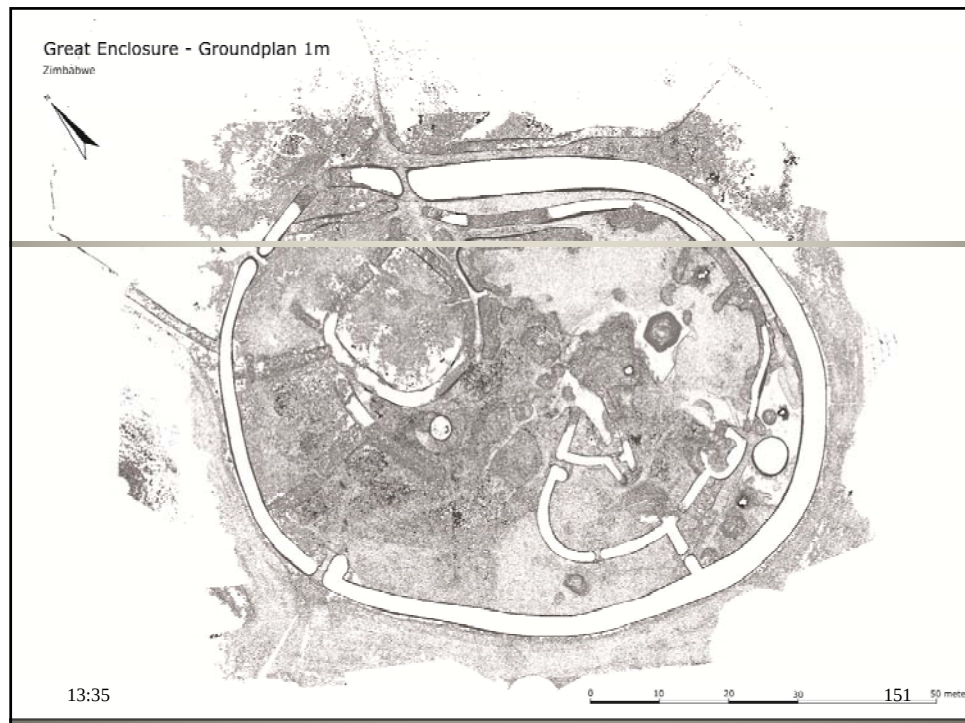
Great Zimbabwe, Zimbabwe





The Great Enclosure in Great Zimbabwe, 11th Century

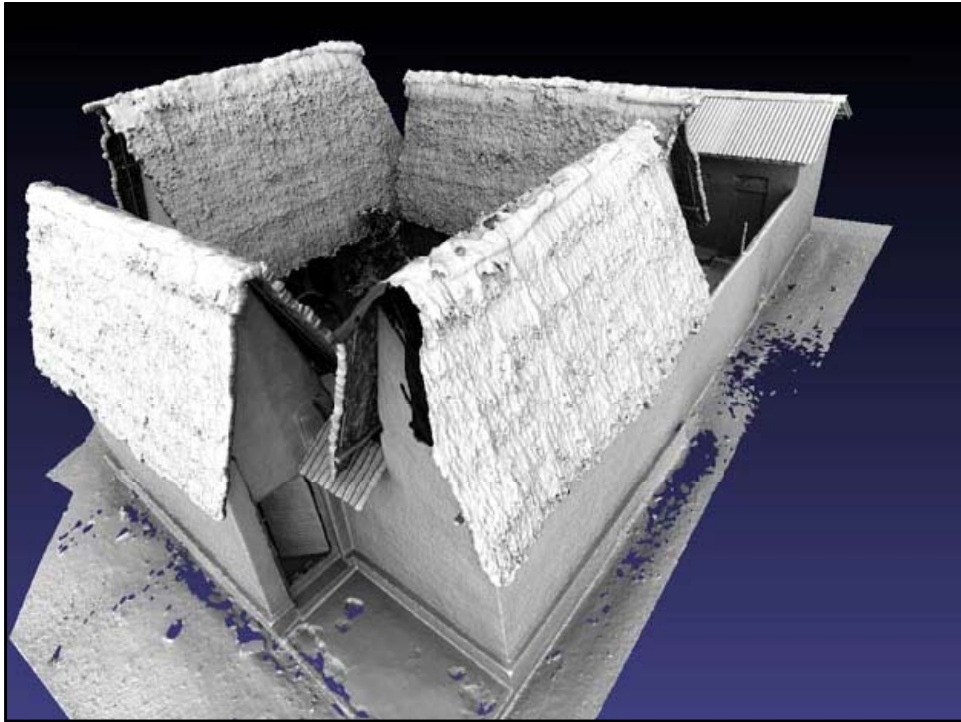




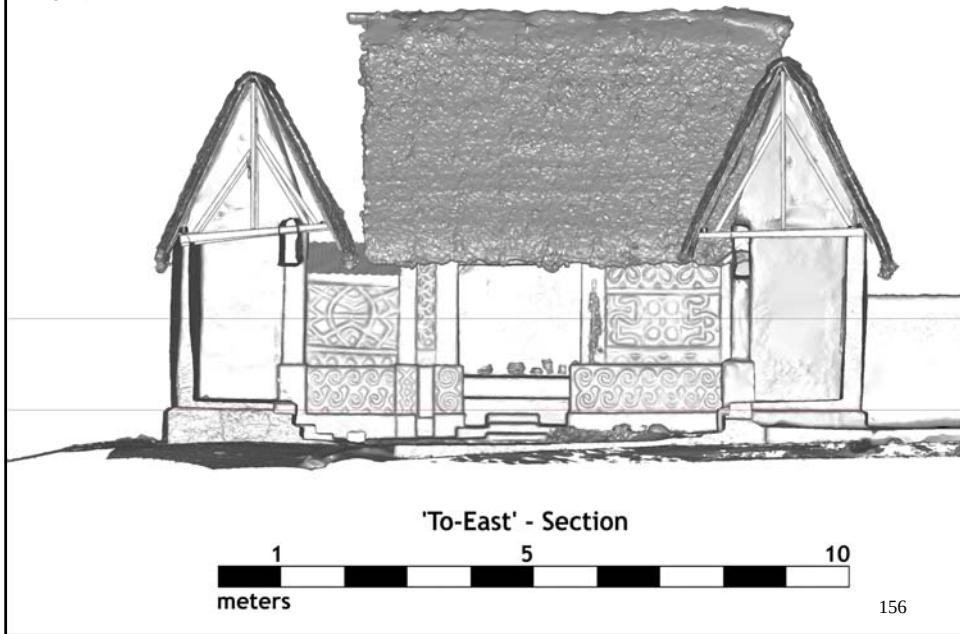
Ghana

Ashanti Shrines (Kumasi)

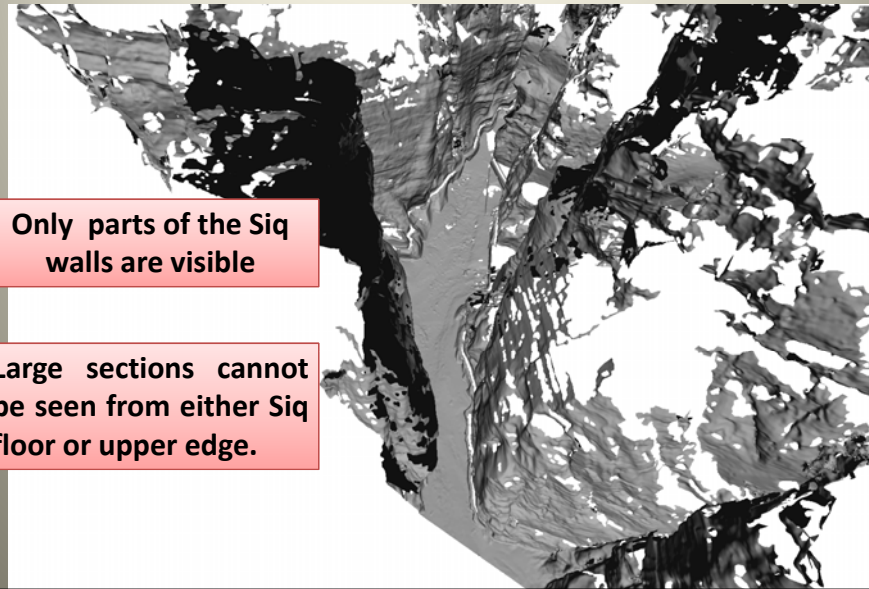




Besease Shrine
Ejisu, Ghana







Only parts of the Siq walls are visible

Large sections cannot be seen from either Siq floor or upper edge.



Top of Siq

