CAPABILITIES AND RESTRICTIONS OF ORTHOPHOTO PROCUCTION SYSTEMS FOR TERRESTRIAL ARCHAEOLOGICAL SURVEYS

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ORTHOPHOTO AT CLOSE-RANGE

- ✓ Orthophoto is an appropriate product for the geometric documentation of cultural heritage
- ✓ Orthophoro consists a level of raster information of a Spatial Information System

- ✓ Special characteristics of archaeological surveys
  - Need for very large plotting scales 1:5 – 1:100
  - Projection problems created by the orientation of intersection planes
  - Complexity of the object's shape
  - Difficulties in taking the appropriate photos
  - Frequent use of non-metric cameras
  - Lack of pre-marked control points

OBJECTIVES OF THE TEST

- Investigation of the possibility of using orthophoto for the documentation of various monument types
- Comparison of the characteristics of Digital Orthophoto production systems
- Definition of the difficulties in orthophoto implementation

Digital Photogrammetric Systems
available for comparison

- ImageStation SSK of Z/I Imaging
- SoftPlotter v.2 of Autometric
- VirtuoZo 3.2 for WindowsNT of Supresoft Inc.
- ARCHIS PLUS of SISCAM

BASIC CHARACTERISTICS OF DPS

	SSK	SoftPlotter	VirtuoZo	ARCHIS
Price	60.000 Euro	60.000 Euro	35.000 Euro	25.000 Euro
Operating system	Windows NT	UNIX	Windows 2000 NT4.0	Windows 98 NT
Special H/W	Graphic card Special mouse	N	Graphic card	Twin mouse
Relative Orientation	Automatic Stereo view	Automatic Mono view	Automatic Mono view	Semi-auto Stereo view
Triangulation	Y	Y No blunder detection	N	N
Automatic DTM/Contour	Y	Y	Y	Y
Ortho/Mosaic	Y	Y	Y	Y
Restitution	Y	Y	Link into Microstation	Special module

CHARACTERISTICS OF THE TEST FIELDS

- Archaeological surveys of large scales, varying from 1:10 – 1:100
- Objects with high level of detail
- Highly curved objects of non-developable surfaces
- Use of metric and non-metric cameras

TEST FIELDS

(1) Façade of a MOSAIC in the interior of Byzantine Monastry

- Orthophoto scale 1:10
- Non-metric camera (Hasselbland)
- Non pre-marked control points

- Inside view of the DOME of a Byzantine church
  - Orthophoto scale 1:25
  - Metric camera (Zeiss UMK)
  - Non pre-marked control points
- Section of a **CYCLOPEAN TOMB**
  - Orthophoto scale 1:50
  - Non-metric camera (Rolleiflex)
  - Pre-marked control points
- Façade of a **Byzantine TOWER**
  - Orthophoto scale 1:100
  - Metric camera (Zeiss UMK)
  - Pre-marked control points

TEST FIELD 1: Mosaic of Annunciation

- Dimensions:2.75 m x 1.73 m x 0.40 m (depth)
- Photo scale 1:25
- Number of stereomodels: 6
- Number of measured control points: 49

Object shape: pendentive
i.e. two cylinders crossing at 90^{o}

TEST FIELD 2 : Upper view of Dome

- Dimensions:10 m x 10 m x 7.75 m (height)
- Photo scale 1:80
- Number of stereomodels: 1
- Number of measured control points: 13

Shape of the main part of the object: Semi-sphere

TEST FIELD 3: Section of Cyclopean Tomb

- Dimensions: 12.20 x 4.25m x 1.50m (depth)
- Photo scale 1:100
- Number of stereomodels: 4
- Number of measured control points: 22

Object shape: Cone

TEST FIELD 4: Facade of Byzantine Tower

- Dimensions: 26.60 x 6.80 m
- Photo sale 1:150
- Number of stereomodels: 4
- Number of control points: 13

Object shape: Cone (Lower part)
& Cylinder (Upper part)

EVALUATION

1. ORIENTATION RESULTS

Quantitative

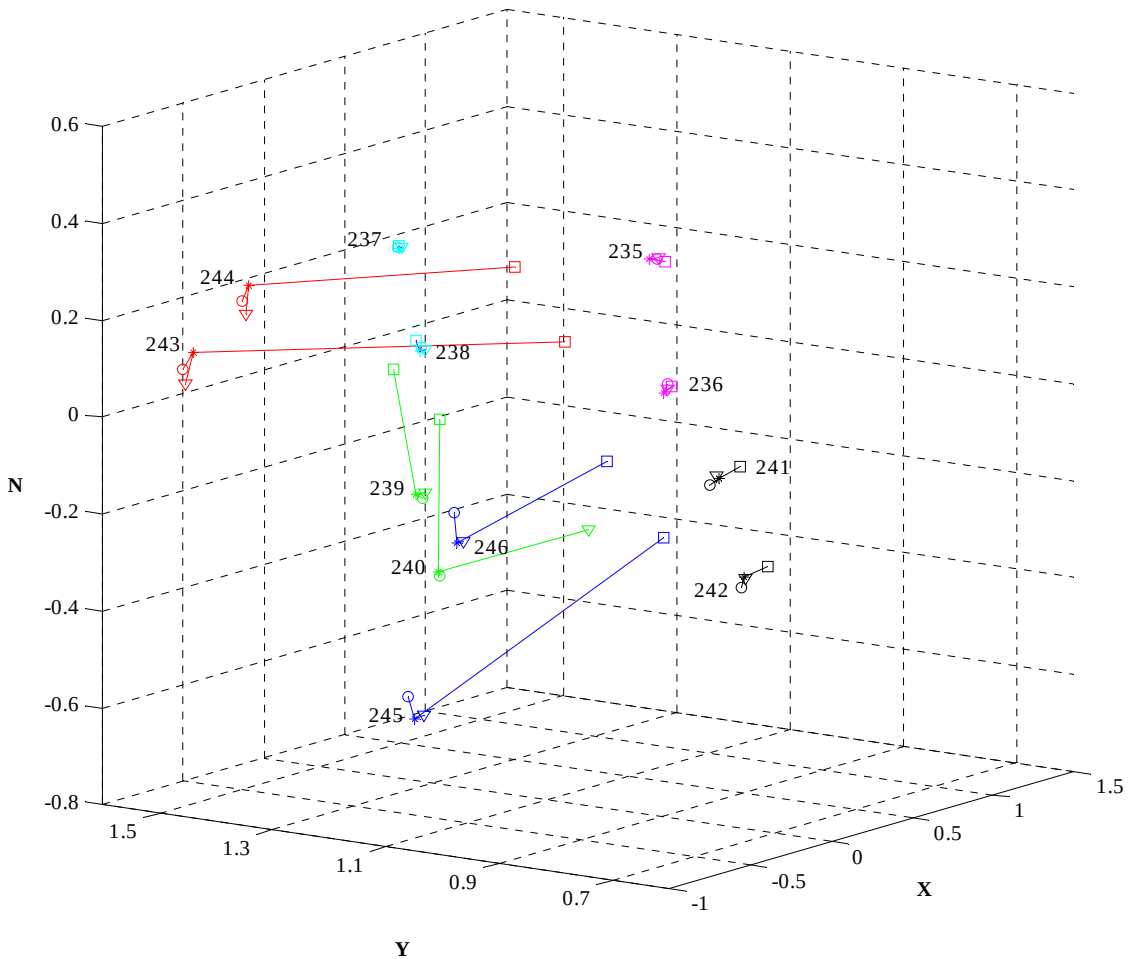
- The orientation results vary significantly for each DPS, especially between SoftPlotter and the others
- The accuracies are influenced, differently for each DPS, by the relative direction of the srereo-pair base and the object
- Some model failed to orient on SoftPlotter and VirtuoZo

Qualitative

- Great differences in DPS friendliness, for the orientations
- Stereo observation very important for detailed objects
- Varying statistical reports from each system

DIFFERENCES OF (Xo, Yo, Zo)

MODELS OF TEST FIELD 1



x SSK

SoftPlotter

∘ ADA

▽ VirtuoZo

X-Grid: 50cm

Y-Grid: 20cm

Z-Grid: 20cm

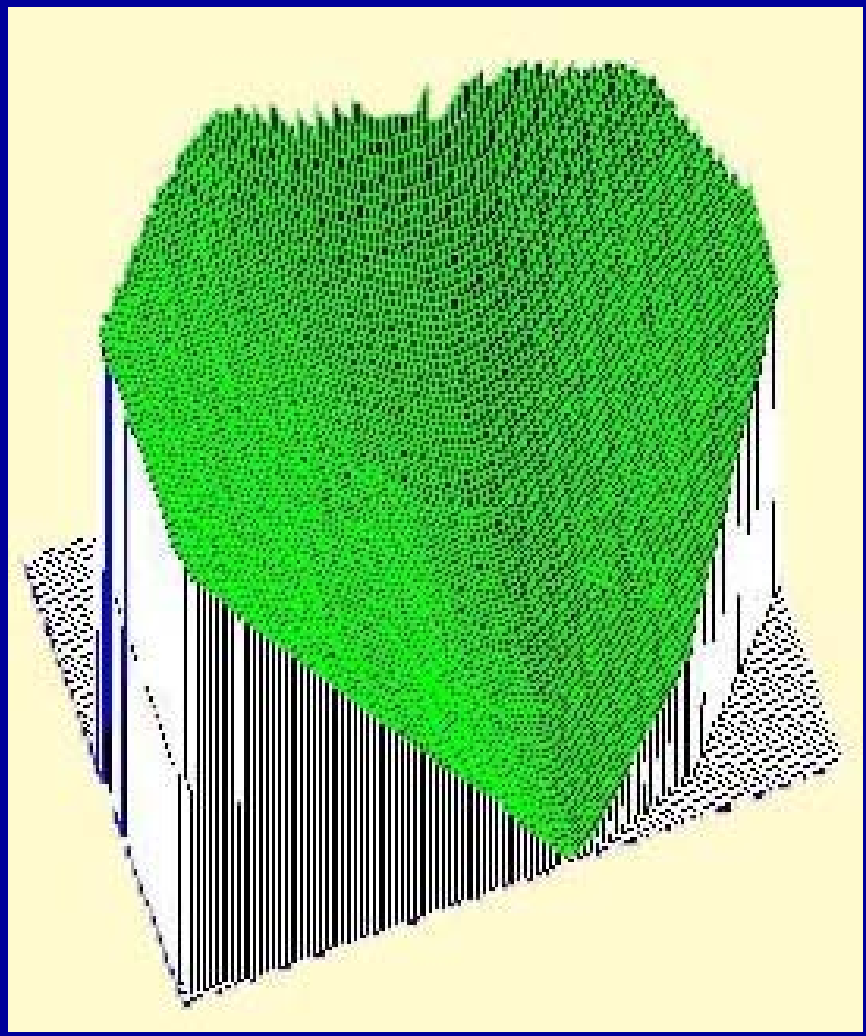
EVALUATION
2. DEM COLLECTION

VirtuoZo was proved unable to form a DTM grid when the spacing is <10cm

- Automated DEM generation gave very few ‘good points’ in all DPS
  - <10% success
  - Large number of ‘good points’ proved to be wrong
- The object characteristics are critical for automated DEM collection
  - Bigger errors appeared at the mosaics
  - Damaged stone-walls need more breaklines
- Different results in automated DEM generation from each DPS
  - VirtuoZo gave the best results, despite the restricted interaction in the extraction strategies
  - ARCHIS have difficulties in automatic detection of points – the DTM extraction strategy is ‘black box’

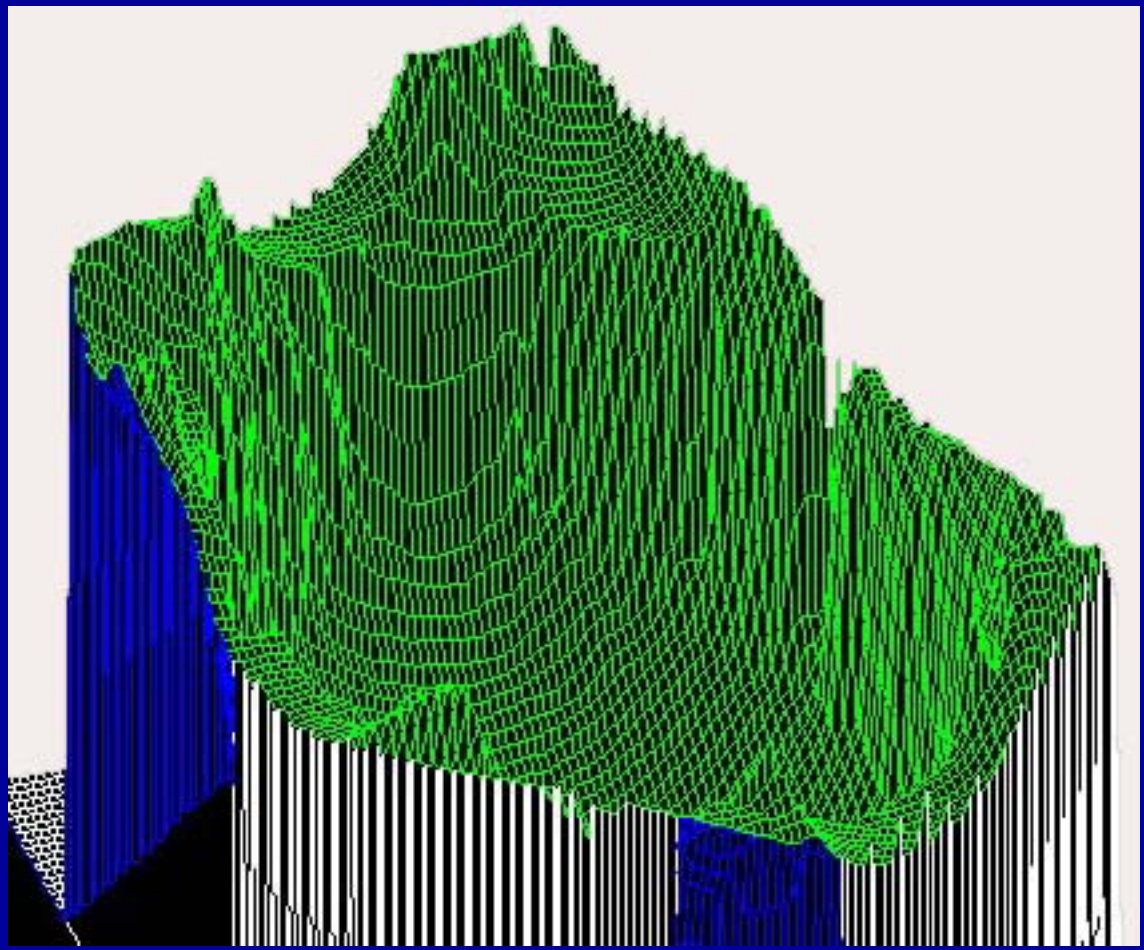
All DEM were measured manually in all DPS

3D AXONOMETRIC VIEW OF THE DEM GRID OF TEST FIELD 1



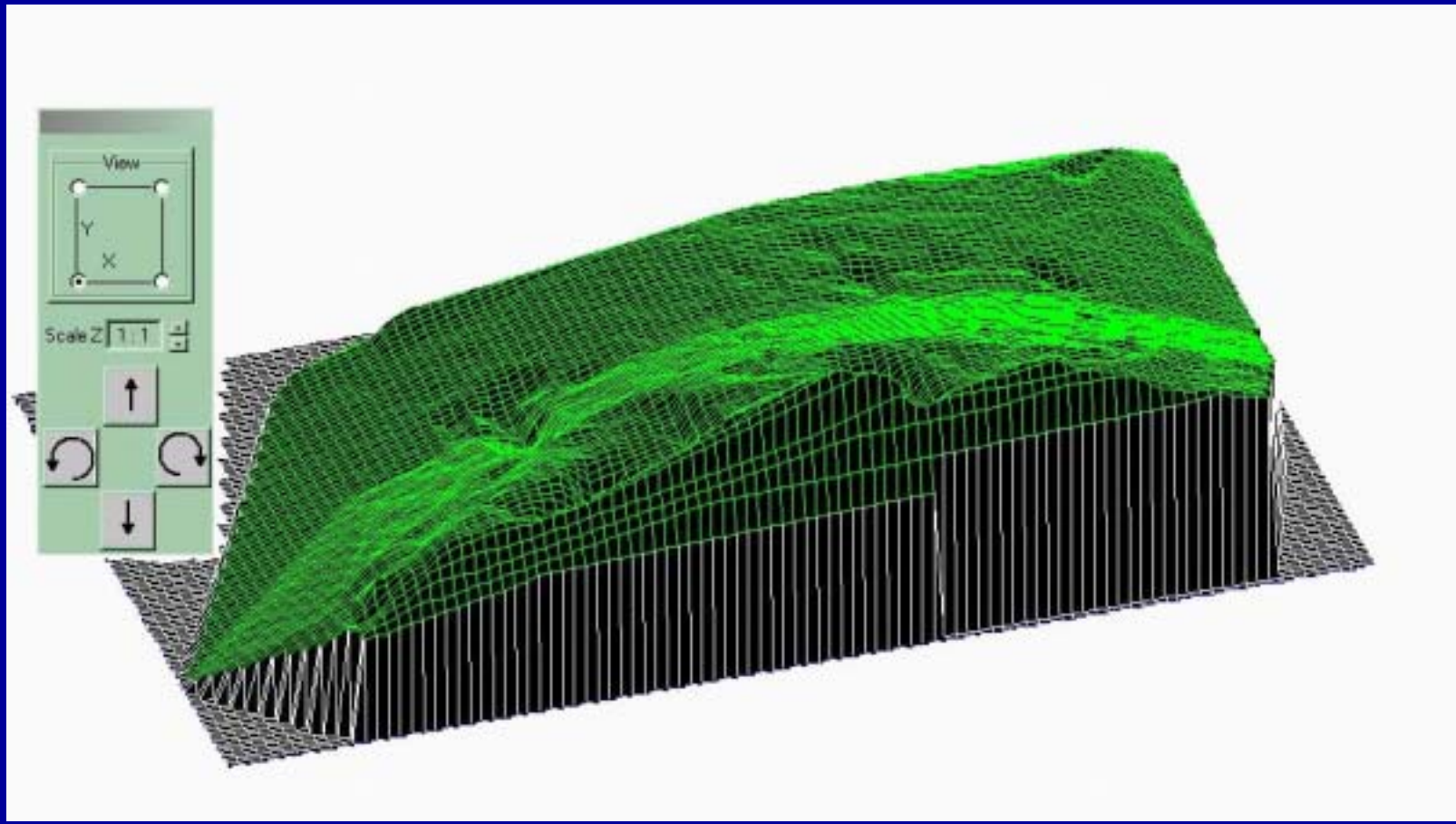
Product from ARCHIS

3D AXONOMETRIC VIEW OF THE DEM GRID OF TEST FIELD 2



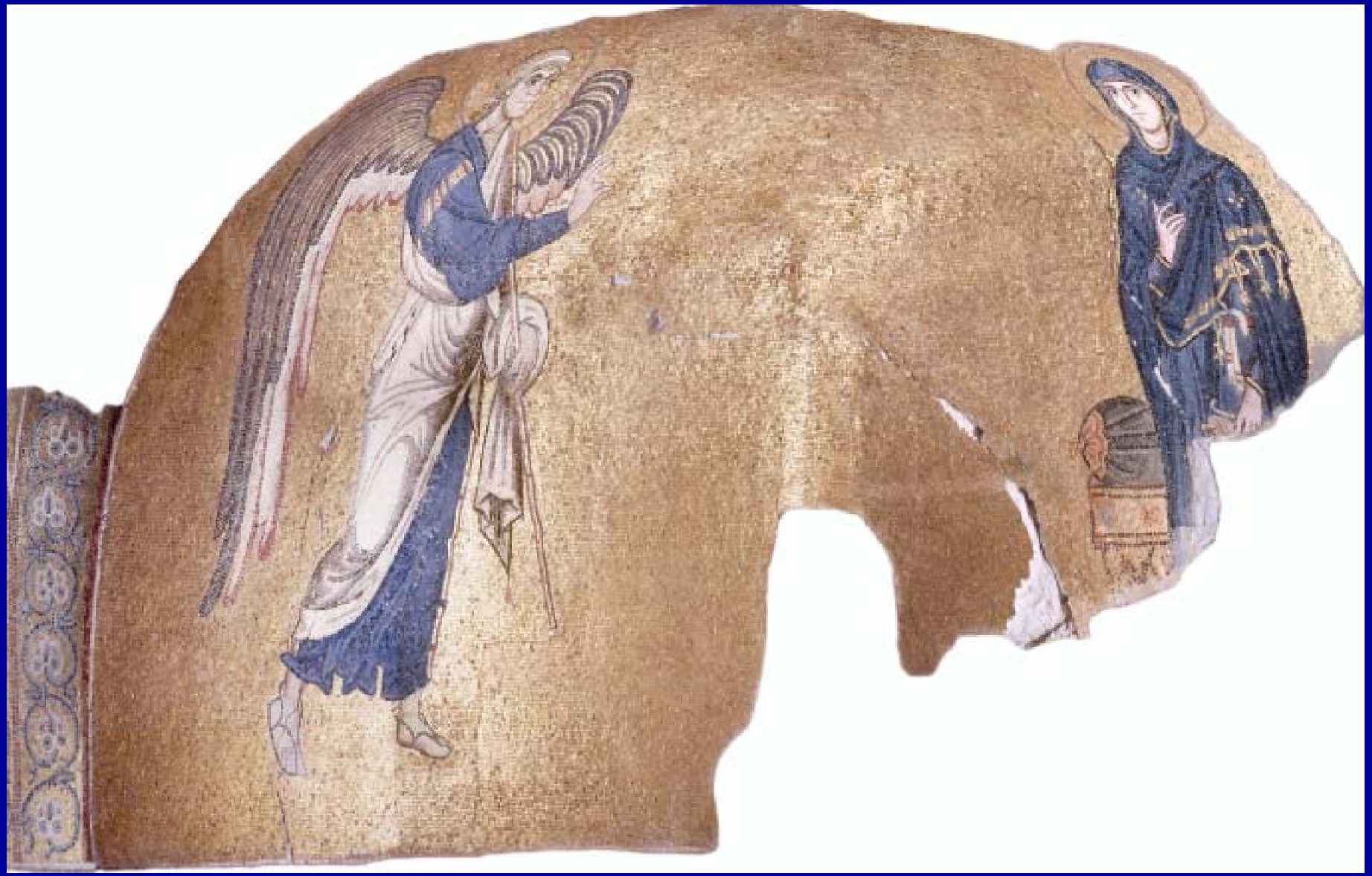
Product from ARCHIS

3D AXONOMETRIC VIEW OF THE DEM GRID OF TEST FIELD 4



Product from ARCHIS

ORTHOPHOTO-MOSAIC: TEST FIELD 1



Product from ARCHIS - pixel size 1mm

VISUAL COMPARISON OF ORTHOPHOTOS

DETAIL OF TEST FIELD 1

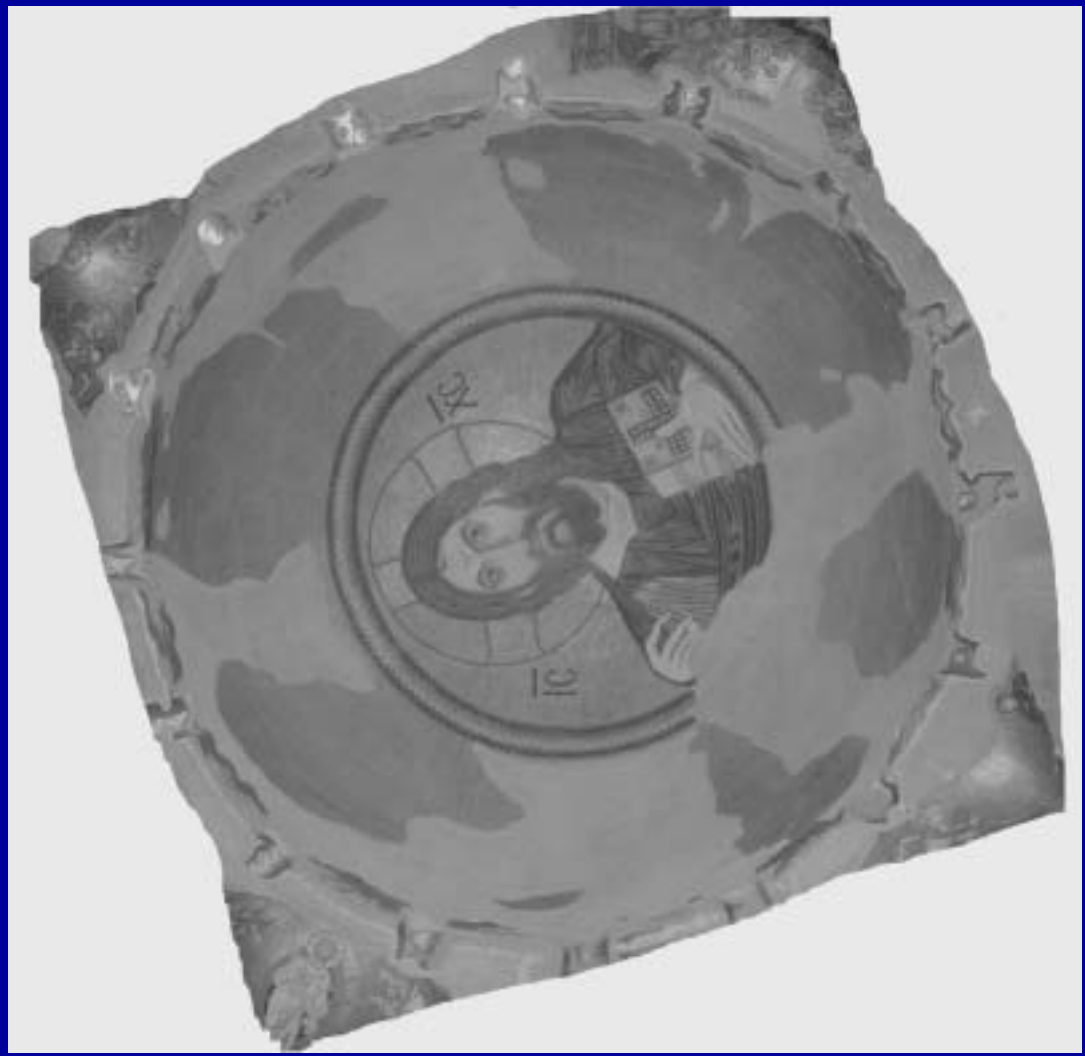
SSK

ADA

SoftPlotter

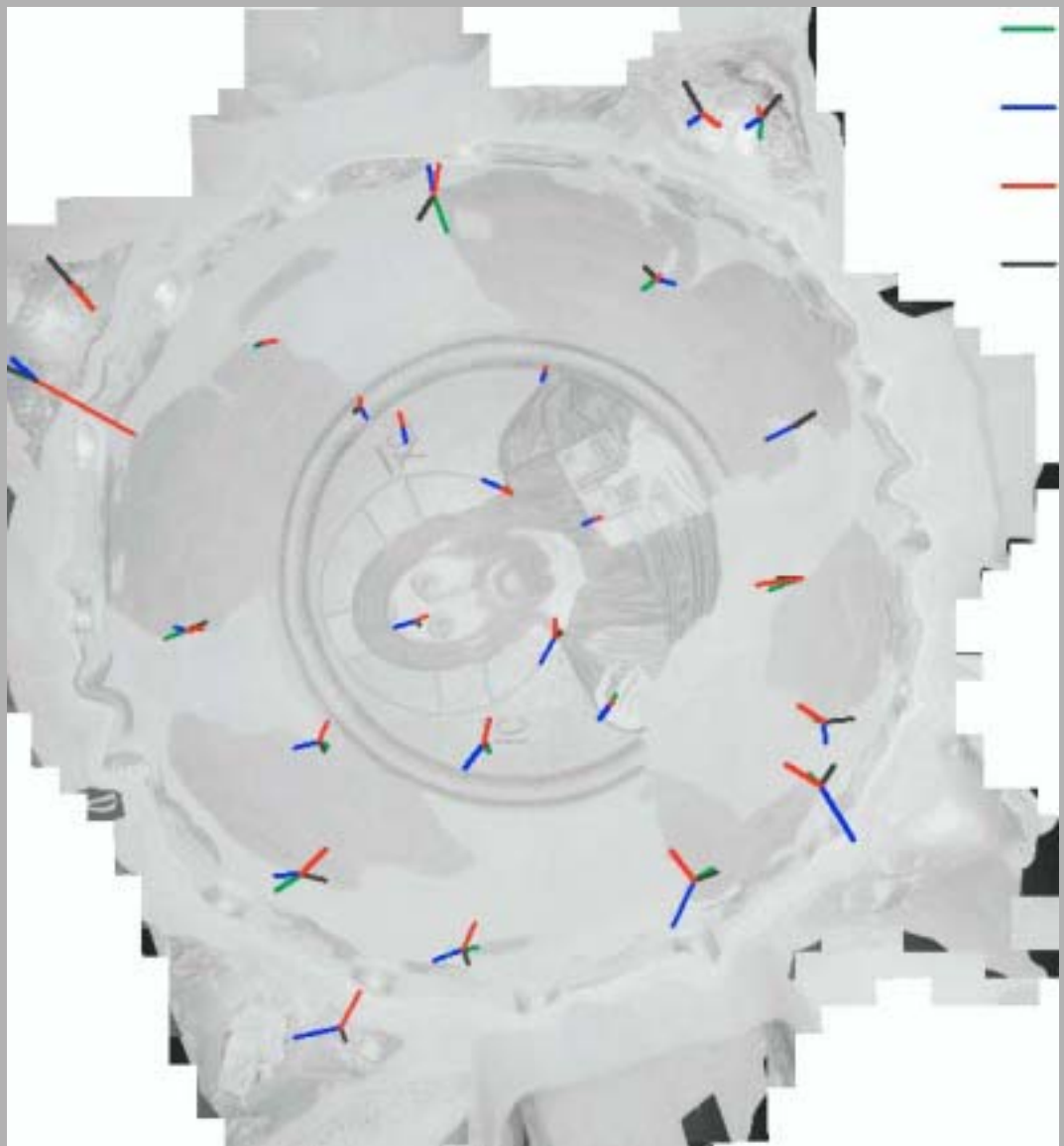
3D VIEW OF THE ORTHOPHOTO-MOSAIC
OF TEST FIELD 1
OVERLAYED ON DSM

ORTHOPHOTOGRAPHY: TEST FIELD 2



Product from SSK - pixel size 2mm

COMPARISON OF ORTHOPHOTOS
OF TEST FIELD 2



SSK

SoftPlotter

VirtuoZo

ARCHIS

3D VIEW OF THE ORTHOPHOTO
OF TEST FIELD 2
OVERLAYED ON DSM

Product from VirtuoZo

ORTHOPHOTO-MOSAIC : TEST FIELD 3

2 out of 4 models

Product from SoftPlotter - pixel size 3mm

VISUAL COMPARISON OF ORTHOPHOTOS

DETAIL OF TEST FIELD 3

SoftPlotter

VirtuoZo

ARCHIS

ORTHOPHOTO-MOSAIC : TEST FIELD 4

3 out of 4 models

Product from ARCHIS - pixel size 5mm

VISUAL COMPARISON OF ORTHOPHOTOS

DETAIL OF TEST FIELD 4

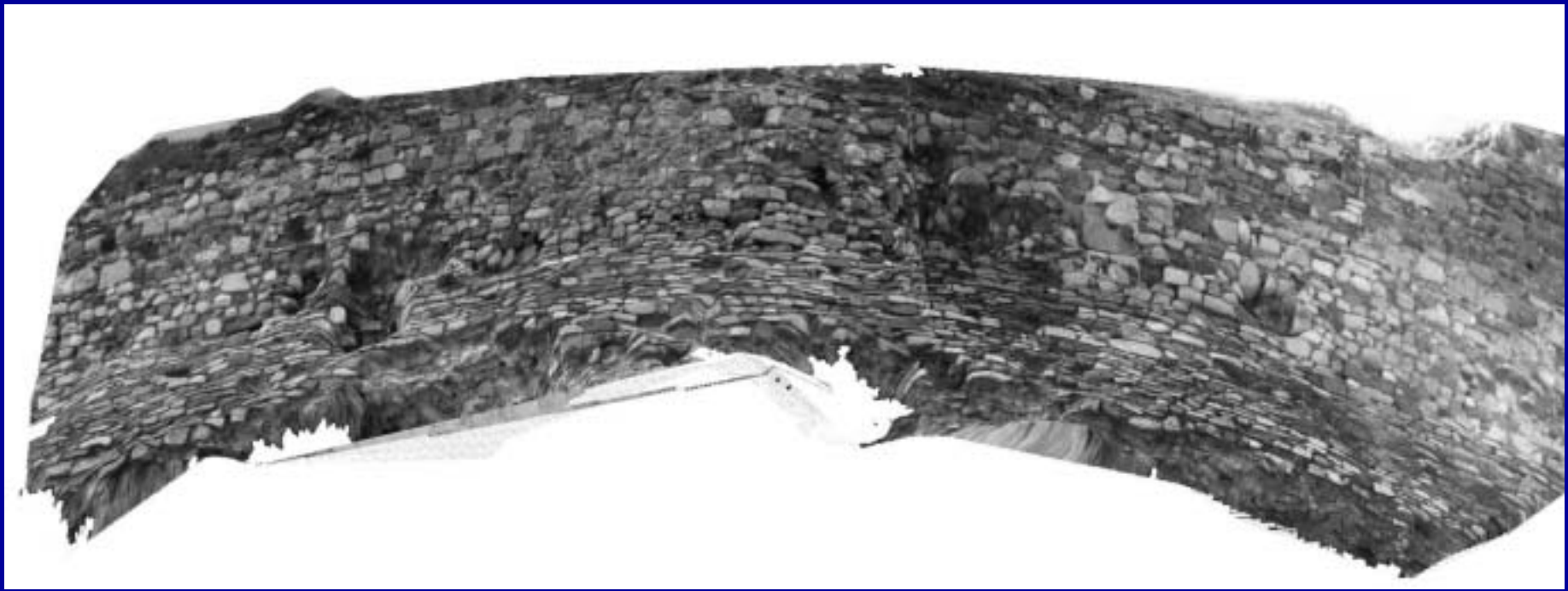
SSK

SoftPlotter

VirtuoZo

ARCHIS

3D VIEW OF THE ORTHOPHOTO-MOSAIC
OF TEST FIELD 3
OVERLAYED ON DSM



Product from ARCHIS

COORDINATE DIFFERENCES BETWEEN SSK - SoftPlotter

	Test field 1 30 check points	Test field 2 27 check points	Test field 3 15 check points	Test field 4 19 check points
r.m.s. (DX)	20 mm	10 mm	65 mm	35 mm
max (DX)	48 mm	24 mm	107 mm	60 mm
r.m.s. (DY)	17 mm	11 mm	12 mm	17 mm
max (DY)	40 mm	26 mm	20 mm	32 mm

COORDINATE DIFFERENCES BETWEEN SSK - VirtuoZo

	Test field 1	Test field 2 28 check points	Test field 3 15 check points	Test field 4 20 check points
r.m.s. (DX)	-	7 mm	31 mm	24 mm
max (DX)	-	18 mm	55 mm	44 mm
r.m.s. (DY)	-	8 mm	14 mm	10 mm
max (DY)	-	16 mm	23 mm	21 mm

COORDINATE DIFFERENCES BETWEEN SSK - ARCHIS

	Test field 1 30 check points	Test field 2 28 check points	Test field 3 15 check points	Test field 4 21 check points
r.m.s. (DX)	11 mm	9 mm	16 mm	11 mm
max (DX)	24 mm	17 mm	27 mm	21 mm
r.m.s. (DY)	11 mm	8 mm	13 mm	10 mm
max (DY)	26 mm	16 mm	26 mm	15 mm

ABSOLUTE DEVIATIONS OF CHECK POINTS COORDINATES

	Test field 1 25 check points				Test field 3 15 check points				Test field 4 19 check points			
	DX(mm)		DY(mm)		DX(mm)		DY(mm)		DX(mm)		DY(mm)	
	rms	max	rms	max	rms	max	rms	max	rms	max	rms	max
SSK	15	26	9	12	17	27	25	37	22	39	18	29
SoftPlotter	29	48	12	26	58	85	18	27	49	87	25	48
VirtuoZo	-	-	-	-	35	52	29	45	36	54	23	35
ARCHIS	14	24	6	13	27	50	20	38	27	43	22	33

PROCEDURE ASSESSMENT FOR ORTHOPHOTO PRODUCTION

	SSK	SoftPlotter	VirtuoZo	ARCHIS
User-friendliness	☺ ☺	😐	☺	☺
Functionality	☺	☹	😐	☹
Stereo-observation in orientation	☺	☹	☹	😐
DEM automation DEM editing	😐	☹	☺	☹
Production speed	☺	☺	☺	☺

CONCLUSIONS

Quality of Orthophoto-mosaics

- Good quality in the central parts of the photos or when the srereo-pair base is almost parallel with the object
- Special treatment is required in ‘difficult’ parts of the objects, i.e. larger scale initial photos
- Orthophotos of almost identical appearance are achieved for the smaller archaeological survey scales (TF3 and TF4)

Accuracy of Orthophotos

- Slightly lower accuracy than expected is achieved for SSK, VirtuoZo, ARCHIS
- Orthophotos produced by SoftPlotter are of considerable lower accuracy
- For such applications the ratio between orthophoto and initial photo scales must be small 1.5:1 – 2:1