The Hong Kong Polytechnic University
Department of Land Surveying & Geo-Informatics

Precise Agriculture Lot Boundary Determined by Photogrammetric Modeling

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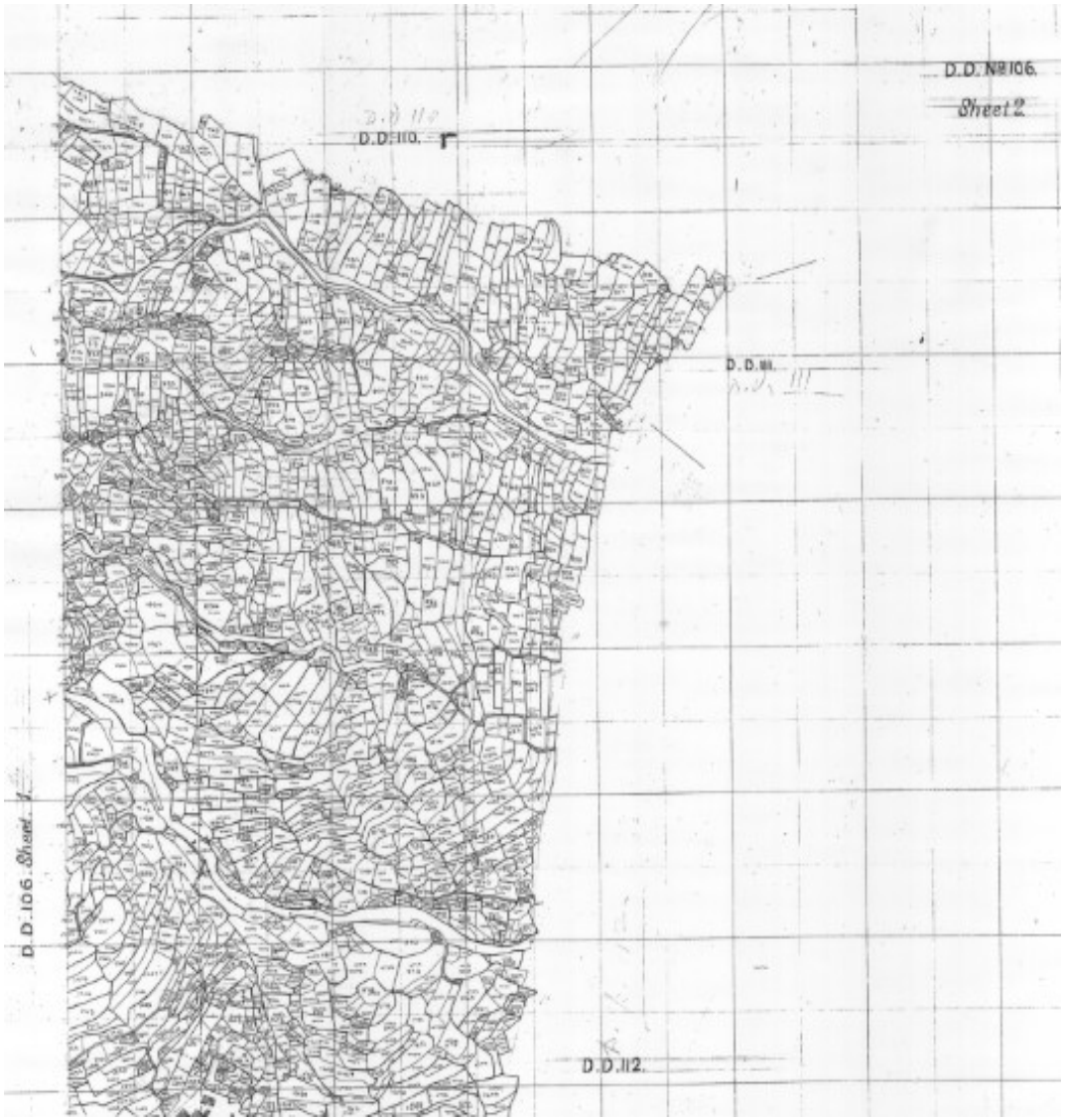
Introduction

Land boundary determination in
the New Territories of Hong Kong

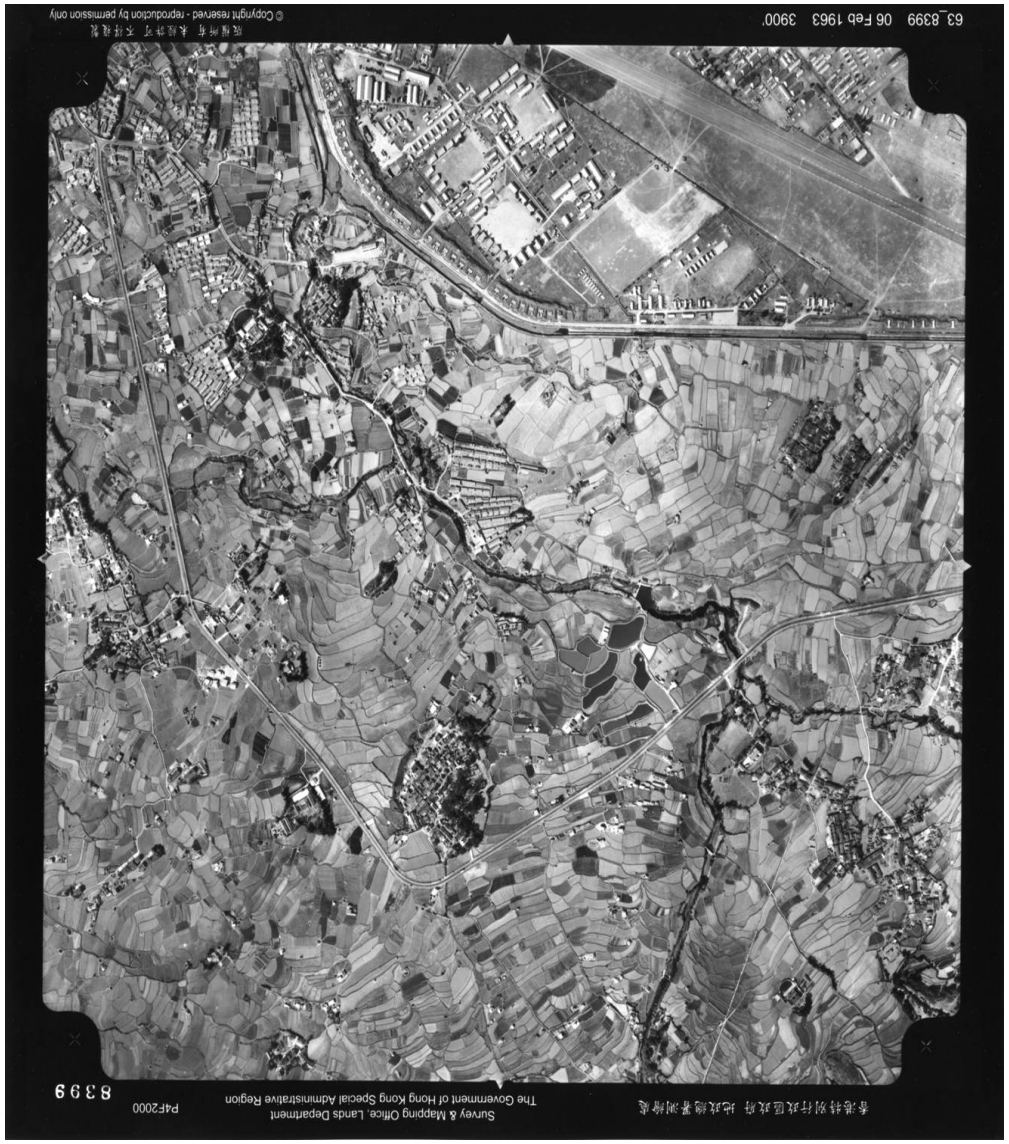
- In the New Territories, the Demarcation District (DD) sheets are still in use as the legal record of land boundaries



- DD sheet: have no coordinates framework

- Limited by the graphic accuracy e.g. 16”DD with only a positional accuracy of 4 m by itself.

- Extrinsic evidence of aerial photos e.g. 1949 and 1963



- Aerial photo: show the features of the time.

- From the 60's photo, field bounds largely maintained as in 1905

- determine agricultural lot boundaries by digital photogrammetry

Digital Photogrammetry

Exterior Orientation

- 1) Geo-referencing old survey sheet, then collect control-point coordinate information

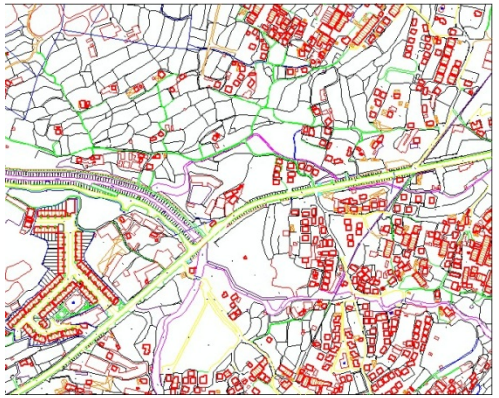
- 2) Field Survey using Kinematic GPS method, collect control-point coordinate information.

Data resources

- 1960, 67, 73 old survey sheet (Yuen Long)

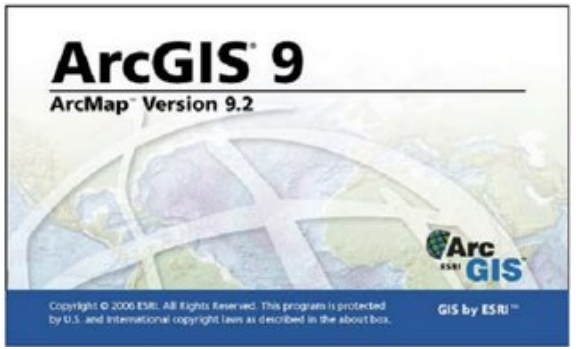
- 1963 aerial photo (Yuen Long, scanned with 1200dpi)

- 2008 Survey Sheet (Yuen Long)

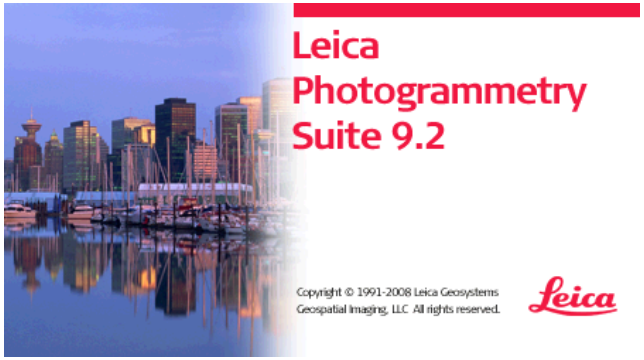


Software adopted

ArcGIS 9.2

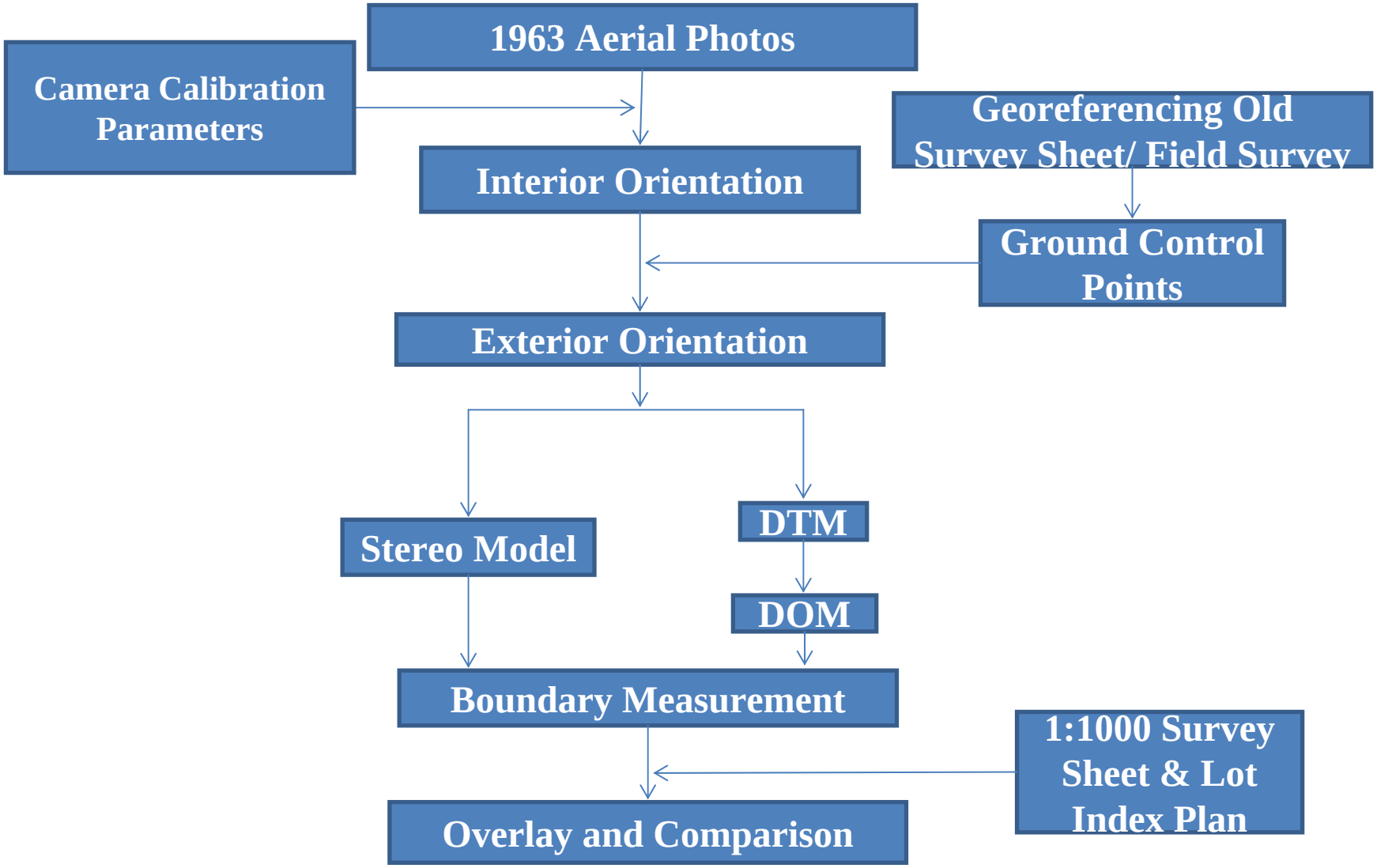


Leica Photogrammetry Suite 9.2

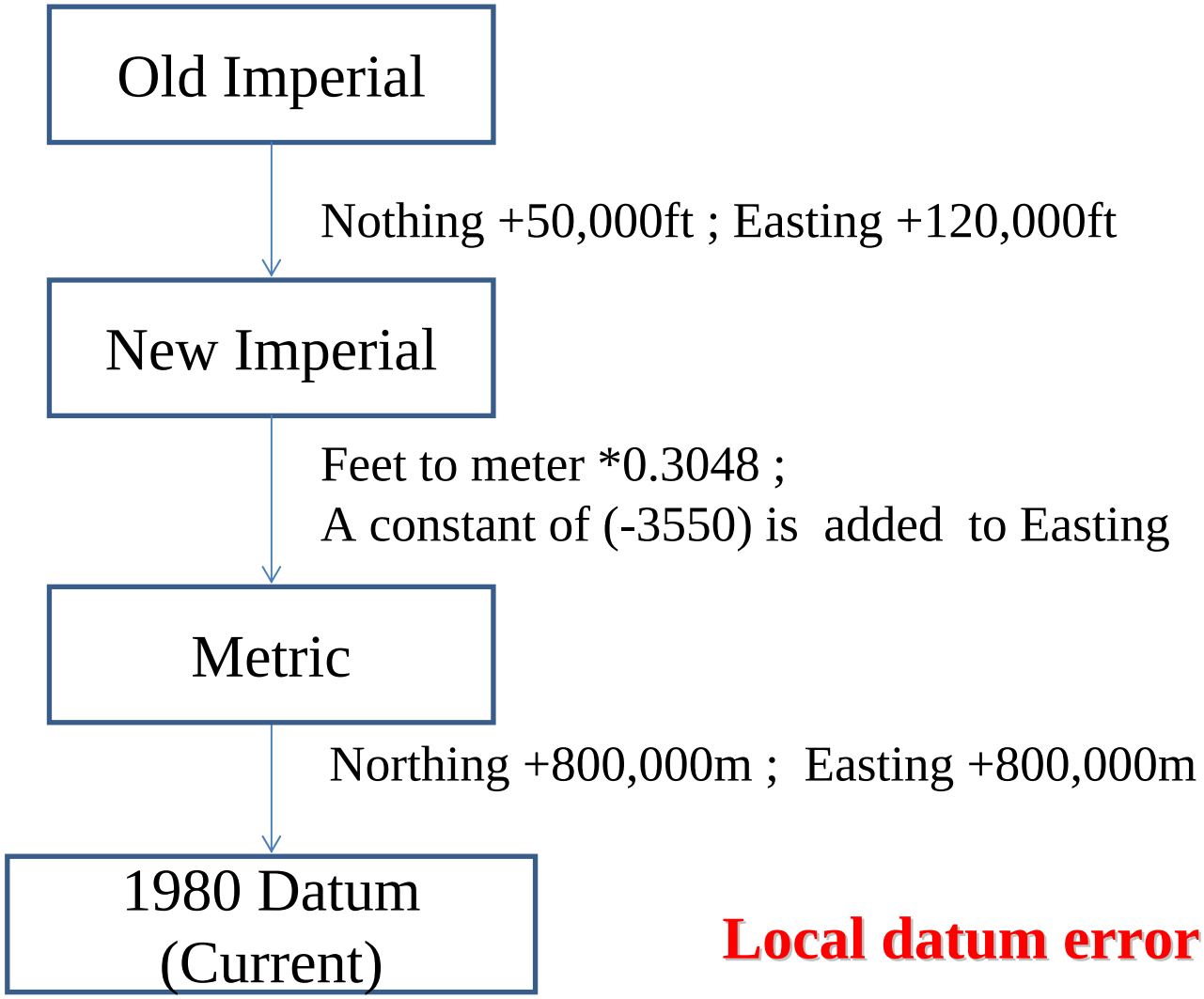


In all these experiments, software processing:
X means Easting;
Y means Northing;

Work Flowchart



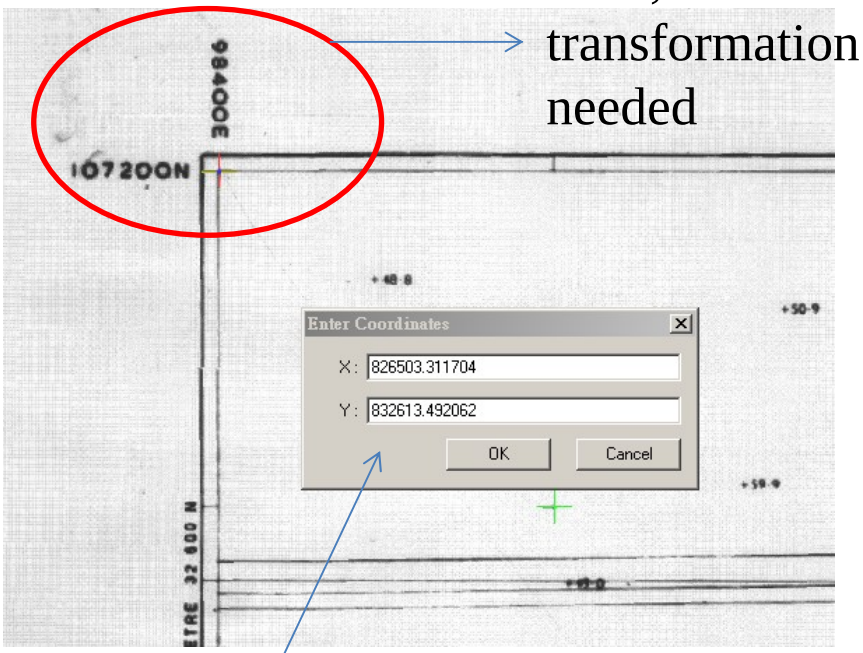
Coordinate Transformation



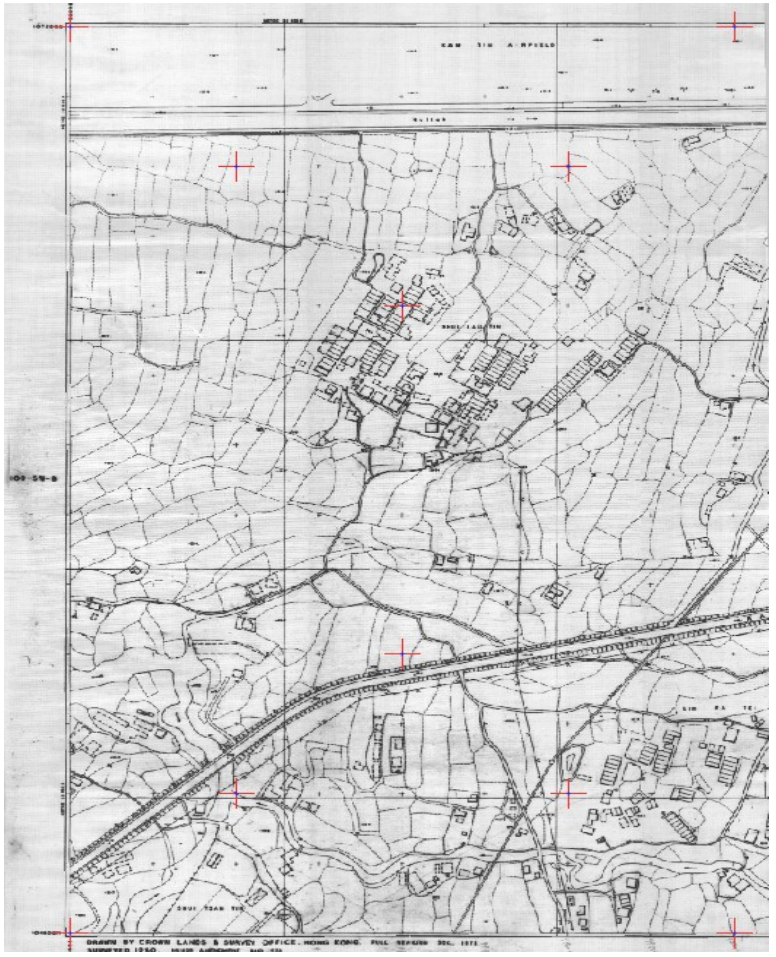
Local datum error may exist !

Georeferencing Old Survey Sheet

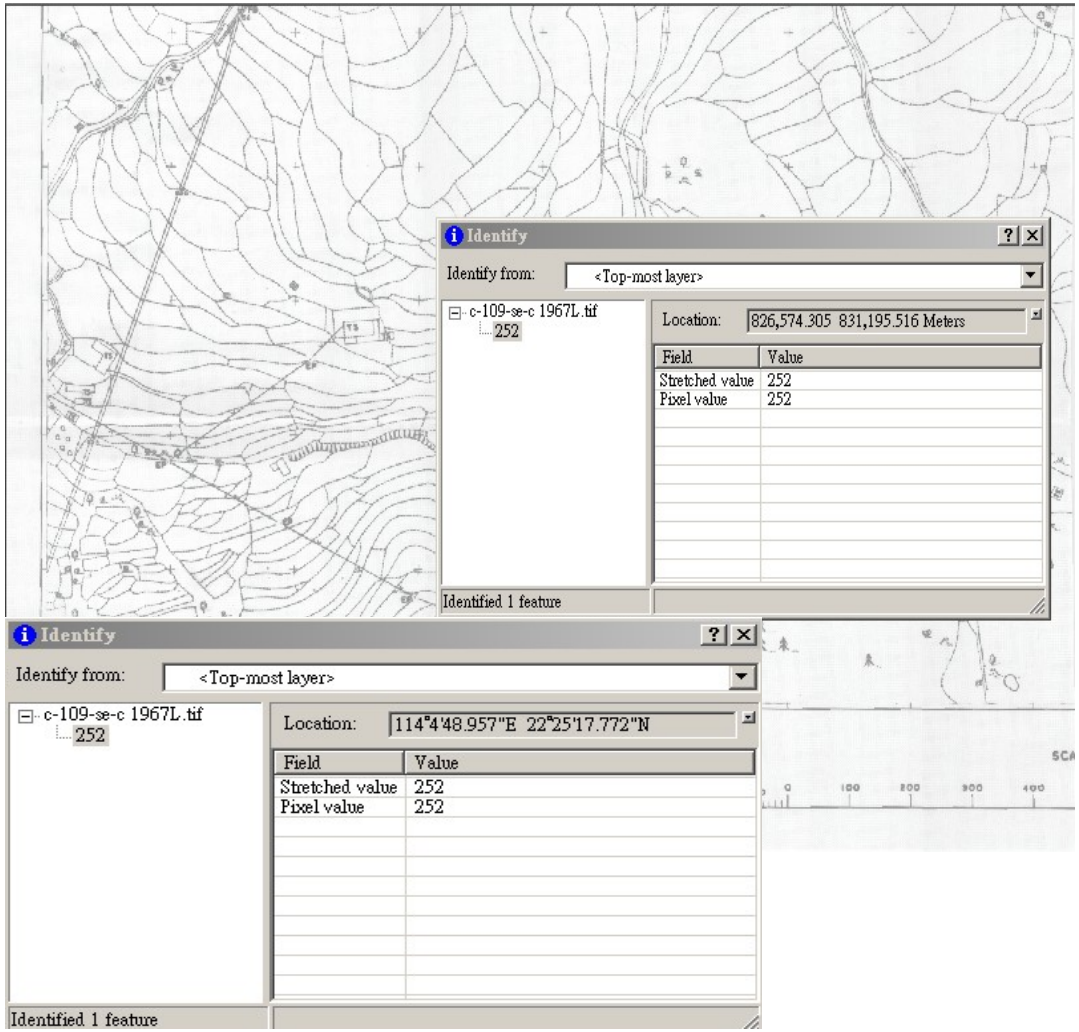
Here, coordinate transformation is needed



Add Control Point:
Coordinate information should be inputted



Then, the old survey sheet can provide features' coordinate information



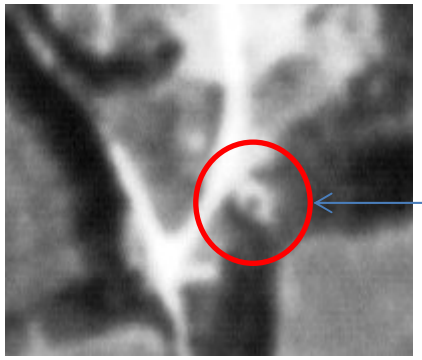
Field Work for control points in exterior orientation

- Adopt wells as the top priority ground control point

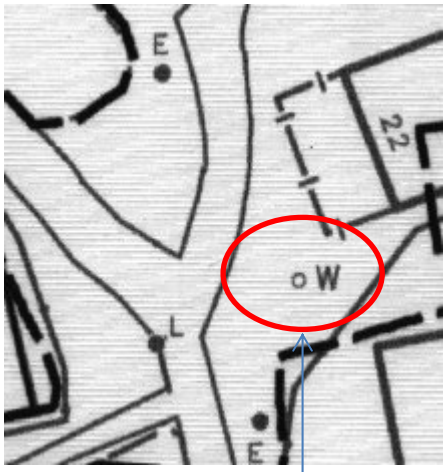
Sensible to believe:

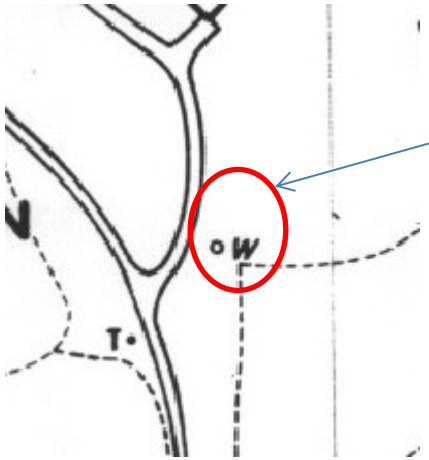
Old wells may be in-use, covered or filled,

but their location can be determined accurately



Well in aerial photo(63)





Well in old survey sheet (73)

Well in lot index plan(2011)

- Kinematic GPS
- Centimeter level

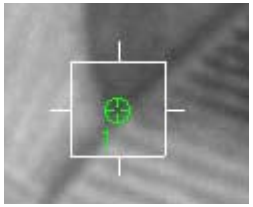
Models with Different Control Points

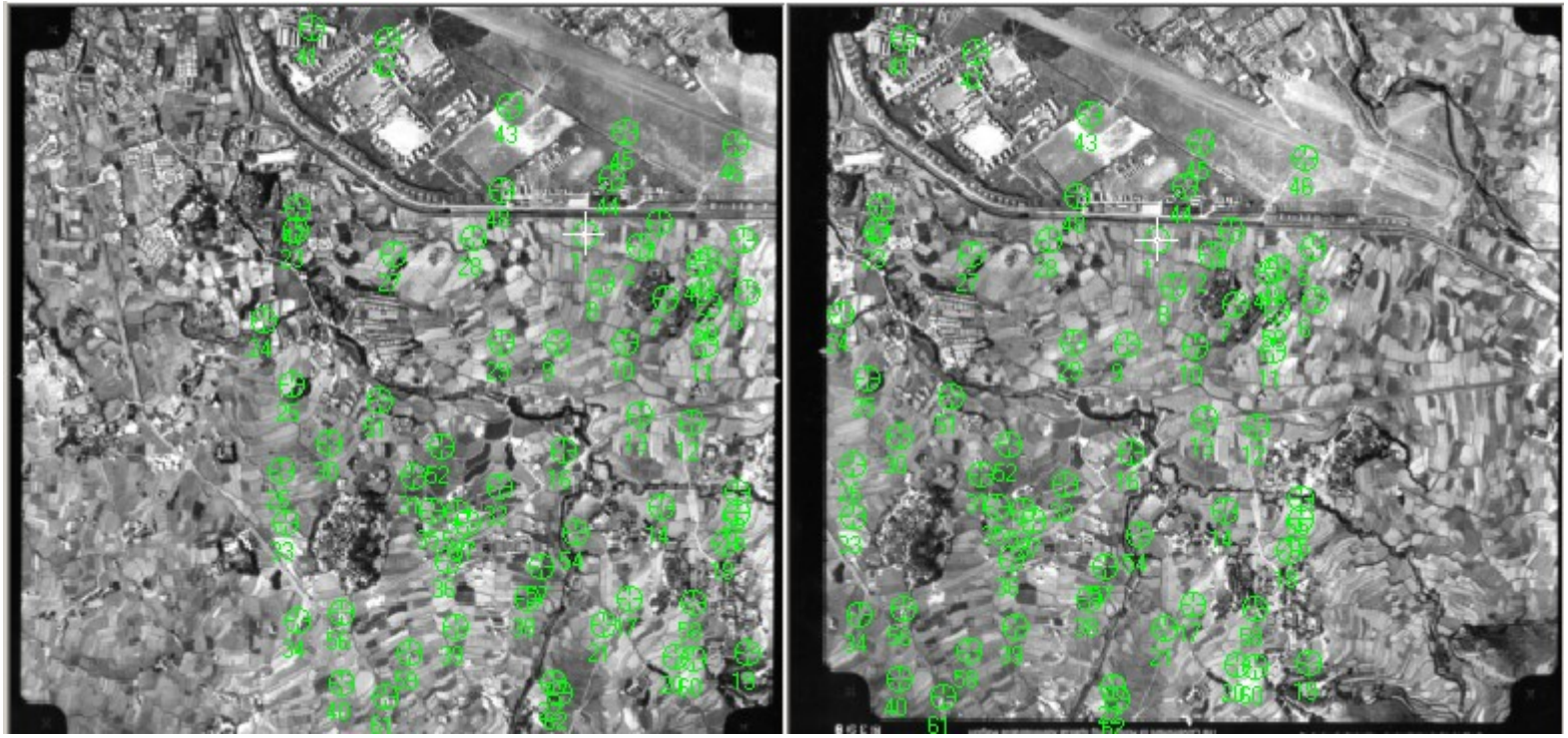
Model Name	GCP Period	GCP Coordinate Source	GCP Type	Number of Control
Model 60 field-bund	1960	Old Survey Sheet Capture	field-bund Crossing	27
Model 67 field-bund	1967	Old Survey Sheet Capture	field-bund Crossing	24
Model 73 field-bund	1973	Old Survey Sheet Capture	field-bund Crossing	25
Model 73 field-bund *	1973	Old Survey Sheet Capture	field-bund Crossing	5
Model 73 Well	1973	Old Survey Sheet Caputre	Old Well	4
Model 2009 Well	2009	RTK Field Collection	Old Well	5

Control Point Distribution

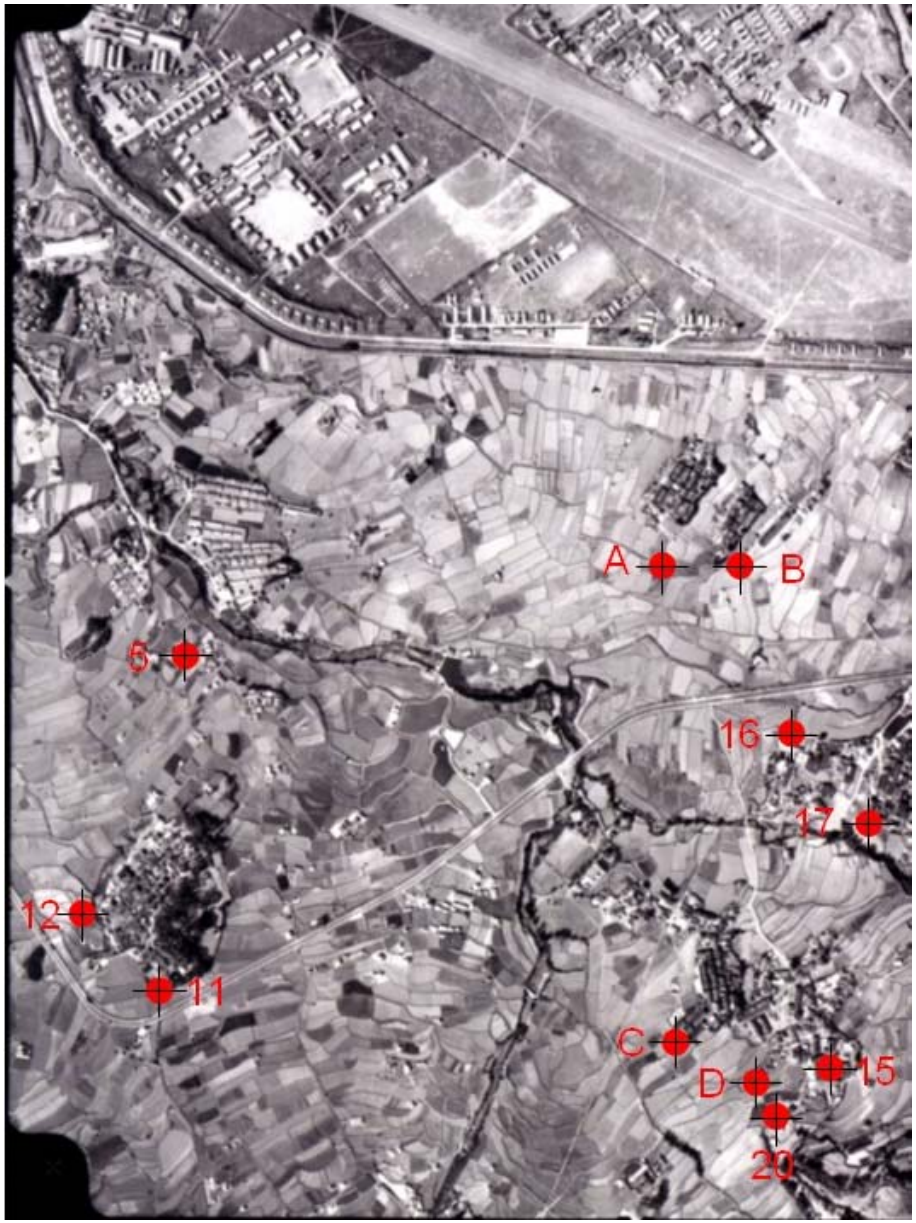
Exterior Orientation using field-bund crossings

Field-bund





Control Point Distribution



Exterior Orientation using old wells (still exist, 2009)

Model 73 Well

Model 09 Well

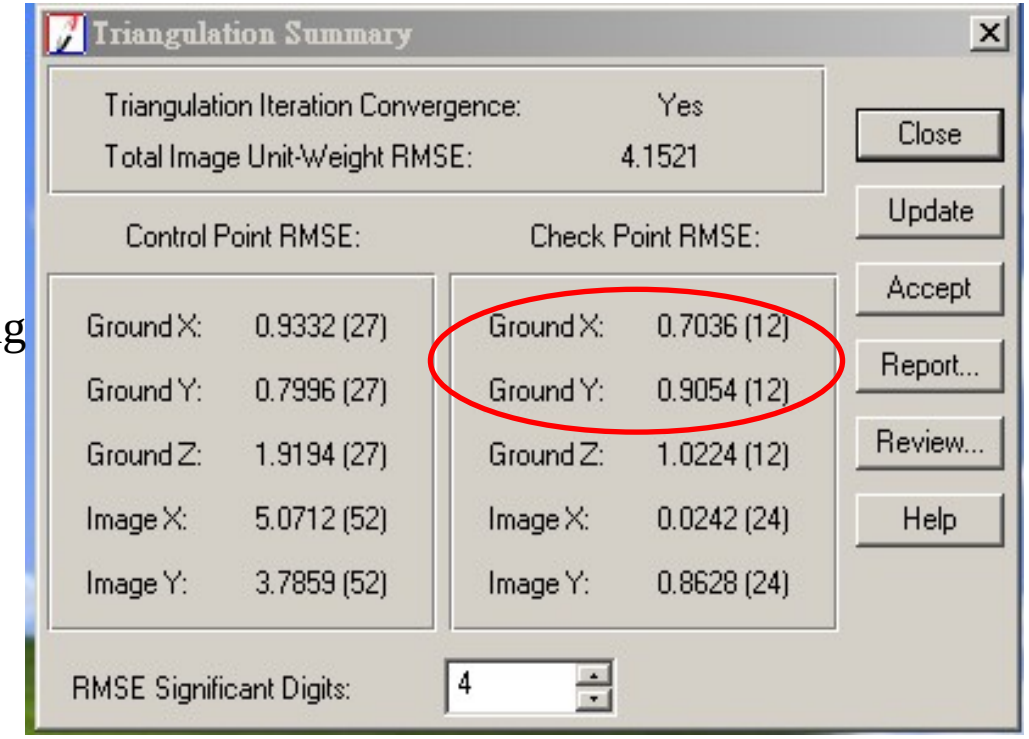
Exterior Orientation in LPS

Model 60 field-bund -- Triangulation Summary (60)

Based on the 60' survey sheet

Control/Check Point
Type: "Y"/"T" field-bund crossing

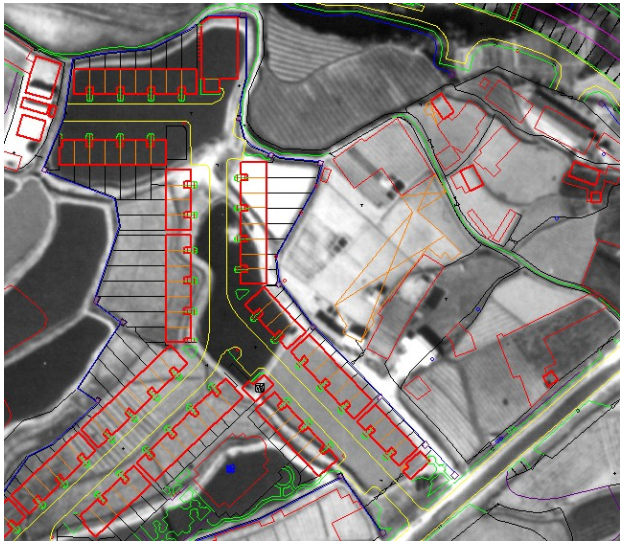
Unit: Meter —Ground
Unit: Pixel –Image



$M_{horizontal}$=1.15m

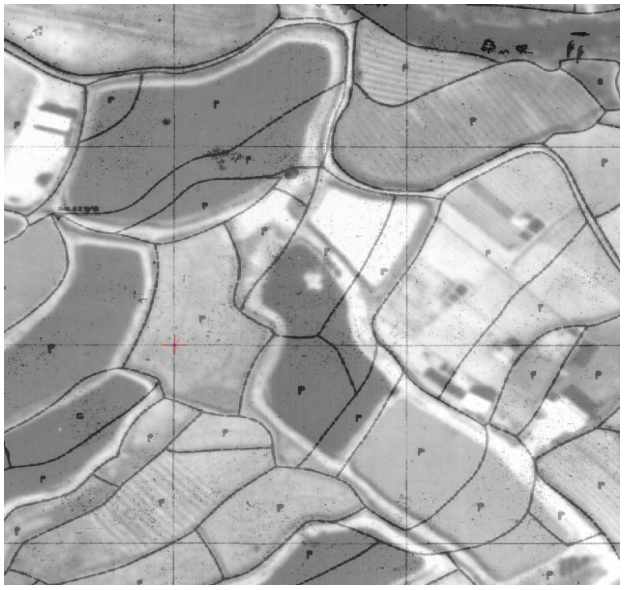
Product : DOM 1960 field-bund

Accuracy can achieved



Application:

Overlap comparison:
1960DOM(field-bund) &
2008SurveySheet(1:1000)



Overlap comparison:
1960DOM(field-bund) &
1960SurveySheet(1:1200)

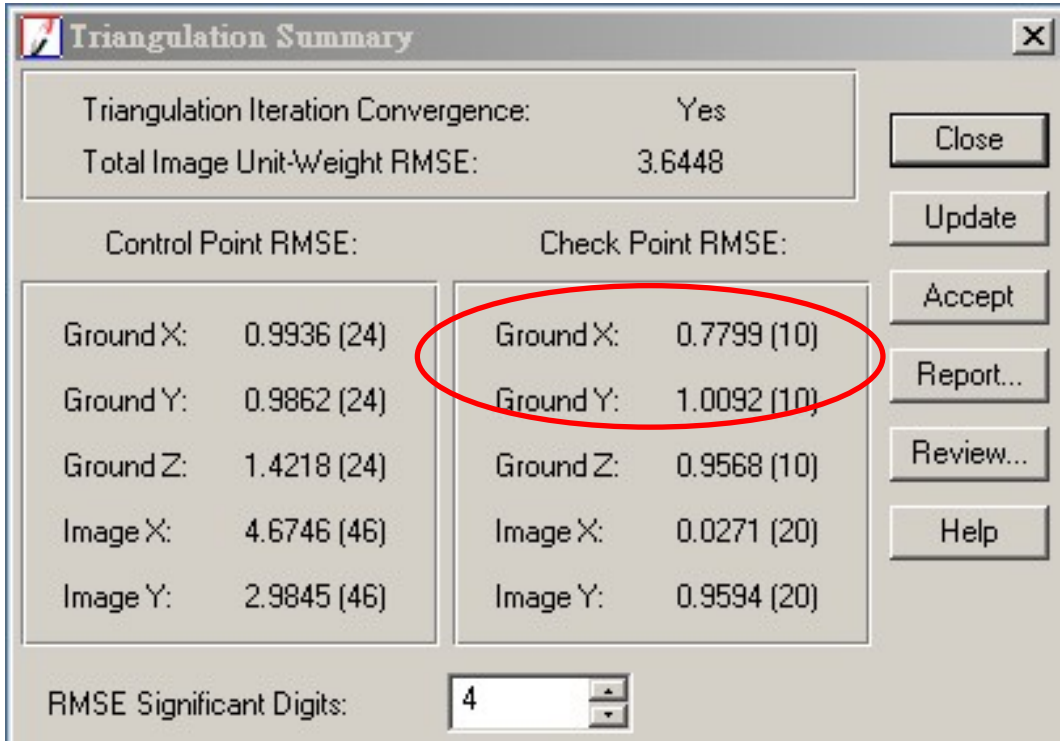
Exterior Orientation in LPS

Model 67 field-bund -- Triangulation Summary (67)

Based on the 67' survey sheet

Control/Check Point
Type: "Y"/"T" field-bund crossing

Unit: Meter —Ground
Unit: Pixel –Image



$M_{horizontal}$=1.28m

Product : DOM 1967 field-bund

Accuracy can achieved

Overlap comparison:
1967DOM(field-bund) &
2008SurveySheet(1:1000)

Overlap comparison:
1967DOM(field-bund) &
1967SurveySheet(1:1200)

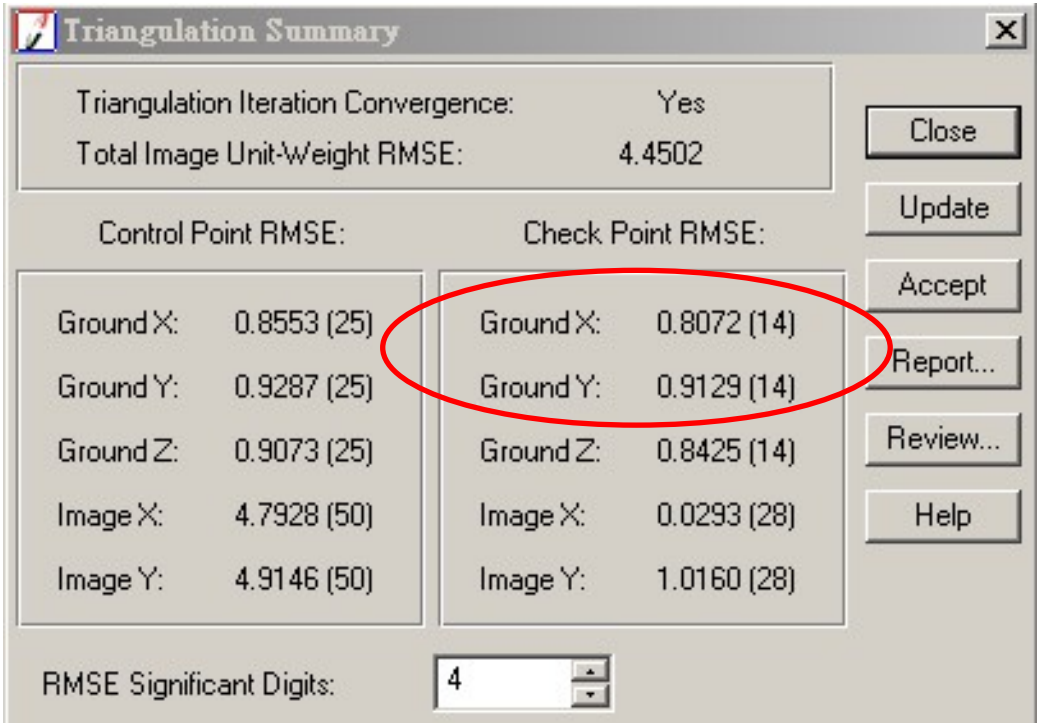
Exterior Orientation in LPS

Model 73 field-bund -- Triangulation Summary (73)

Based on the 73' survey sheet

Control/Check Point
Type: "Y"/"T" field-bund crossing

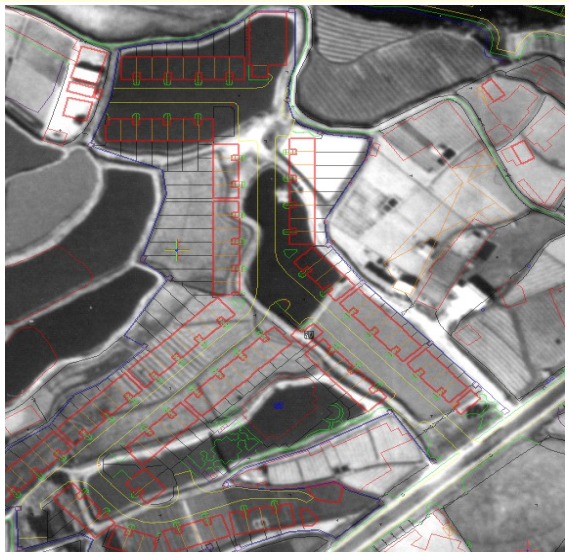
Unit: Meter —Ground
Unit: Pixel –Image



$M_{horizontal}$=1.22m

Product : DOM 1973 field-bund

Accuracy can achieved



Overlap comparison:
1973DOM(field-bund) &
2008SurveySheet(1:1000)

Overlap comparison:
1973DOM(field-bund) &
1973SurveySheet(1:1200)

Exterior Orientation in LPS

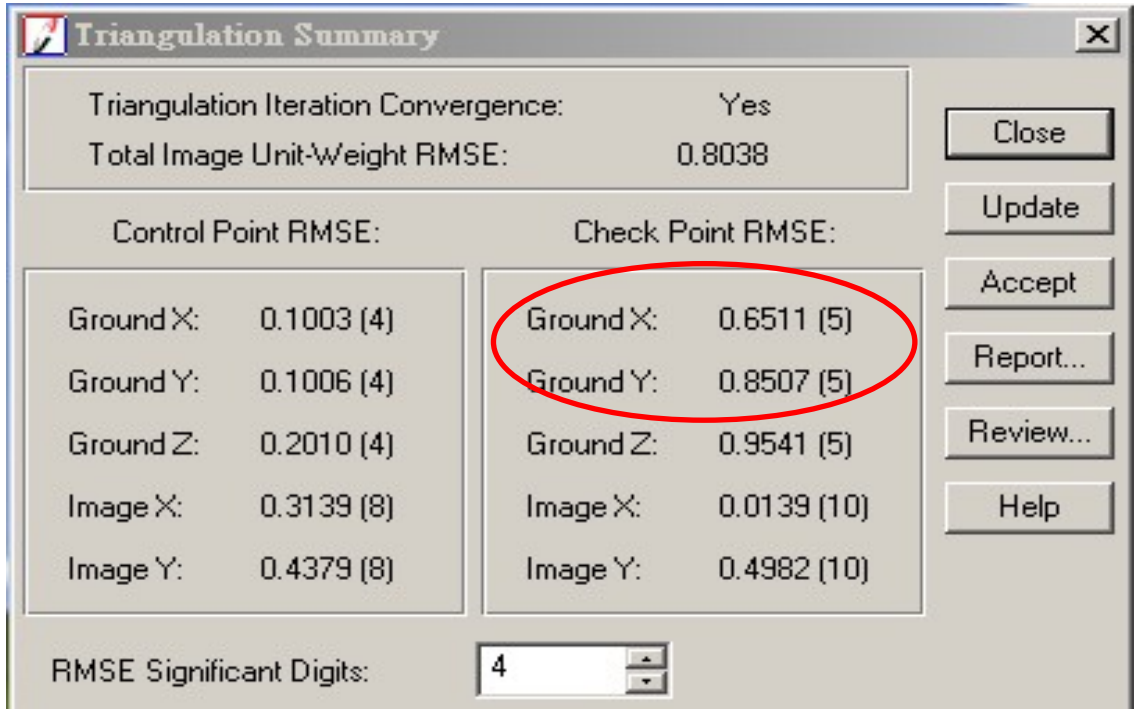
Model 73 well

-- Triangulation Summary (73)

Based on the 73' survey sheet

Control/Check Point
Type: Old well

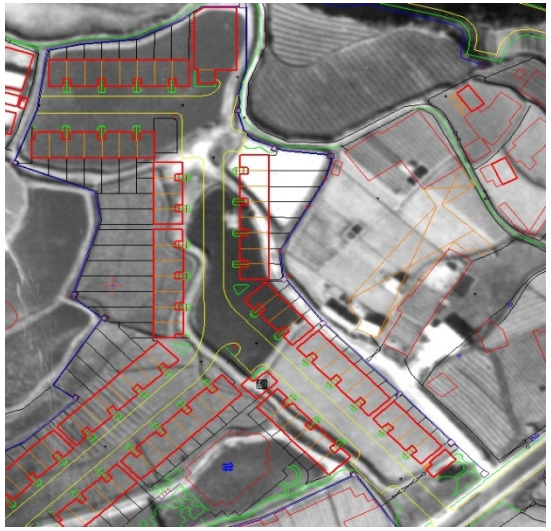
Unit: Meter —Ground
Unit: Pixel –Image



$M_{horizontal}$=1.08m

Product : DOM 1973 well

Accuracy can achieved



Overlap comparison:
1973DOM(well) &
2008SurveySheet(1:1000)

Overlap comparison:
1973DOM(well) &
1973SurveySheet(1:1200)

Exterior Orientation in LPS

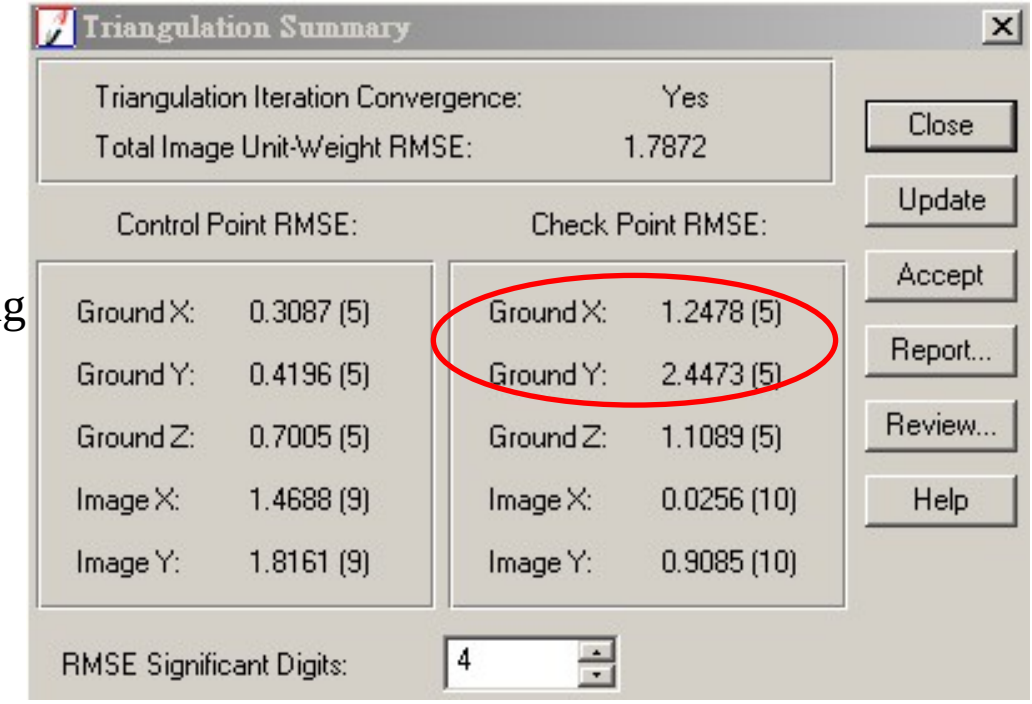
Model 73 field-bund • -- Triangulation Summary (73)

-- similar control point distribution with Model 73 well

Based on the 73' survey sheet

Control/Check Point
Type: "Y"/"T" field-bund crossing

Unit: Meter —Ground
Unit: Pixel –Image



$M_{horizontal}$=2.75m

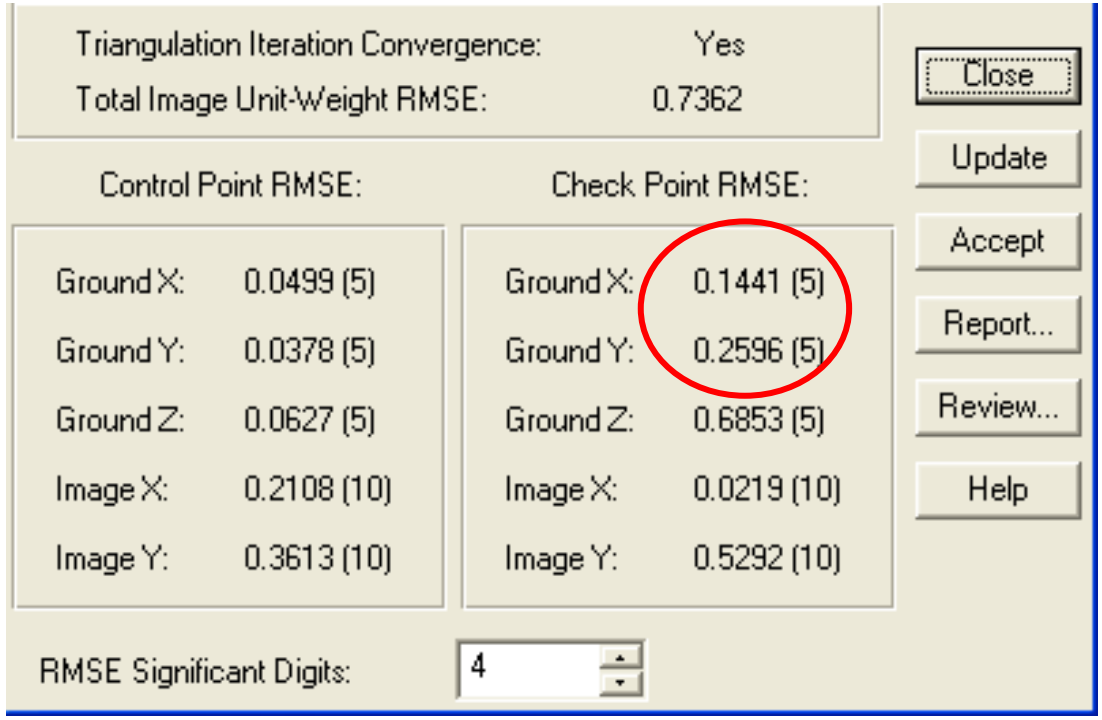
Exterior Orientation in LPS

Model 2009 well -- Triangulation Summary (2009)

RTK technique is used to acquire the coordinate of control point (2009)

Control/Check Point
Type: Old well

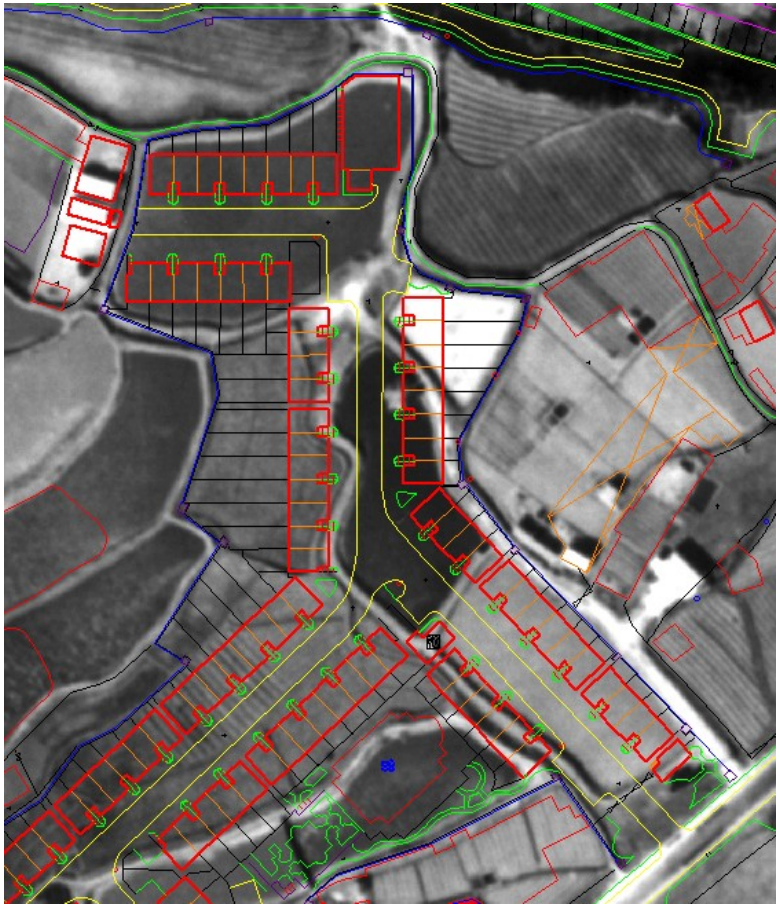
Unit: Meter —Ground
Unit: Pixel –Image



$M_{horizontal}$=0.30m

Product : DOM 2009 well

Accuracy can achieved



Overlap comparison:
2009DOM(well) &
2008SurveySheet(1:1000)

Model 60 field-bund

Using Field Work Result To Test Model Accuracy

Internal Accuracy=1.15m

WellNo.	Xsurvy	Ysurvey	XcaptureFromModel	YcaptureFromModel	Dx	Dy	D(horizontal)
A	826661.21	832303.53	826660.42	832300.51	-0.79	-3.02	3.12
B	826765.06	832306.01	826764.64	832302.90	-0.42	-3.11	3.14
D	826824.97	831596.05	826824.68	831593.52	-0.28	-2.52	2.54
No20(field-bund)	826271.70	831768.01	826271.49	831766.17	-0.21	-1.84	1.85

System error may existed
Using mean to rectify

Model 67 field-bund

Using Field Work Result To Test Model Accuracy

Internal Accuracy=1.28m

1967Model field-bund							
WellNo.	Xsurvy	Ysurvey	XcaptureFromModel	YcaptureFromModel	Dx	Dy	D(horizontal)
A	826661.21	832303.53	826660.27	832303.22	-0.94	-0.31	0.98
B	826765.06	832306.01	826764.66	832305.75	-0.40	-0.25	0.47
D	826824.97	831596.05	826825.84	831595.95	0.87	-0.09	0.88
No20(field-bund)	826271.70	831768.01	826271.80	831767.66	0.10	-0.35	0.36

Model 73 field-bund

Using Field Work Result To Test Model Accuracy

Internal Accuracy=1.22m

1973Model field-bund							
WellNo.	Xsurvy	Ysurvey	XcaptureFromModel	YcaptureFromModel	Dx	Dy	D(horizontal)
A	826661.21	832303.53	826660.56	832303.06	-0.65	-0.47	0.80
B	826765.06	832306.01	826764.57	832305.55	-0.49	-0.46	0.67
D	826824.97	831596.05	826824.95	831596.70	-0.01	0.66	0.66
No20(field-bund)	826271.70	831768.01	826271.64	831768.54	-0.06	0.53	0.54

Model 73 field-bund*

Using Field Work Result To Test Model Accuracy

Internal Accuracy=2.75m

1973Model field-bund*							
WellNo.	Xsurvey	Ysurvey	XcaptureFromModel	YcaptureFromModel	Dx	Dy	D(horizontal)
A	826661.21	832303.53	826660.81	832303.87	-0.40	0.34	0.52
B	826765.06	832306.01	826765.08	832306.40	0.02	0.39	0.39
D	826824.97	831596.05	826826.91	831594.84	1.94	-1.21	2.29
No20(Ran)	826271.70	831768.01	826272.12	831768.69	0.42	0.68	0.80

Model Comparison

1. Model 60 field-bund — 27 control points used in the exterior orientation

$M_{horizontal}$=1.15m

2. Model 67 field-bund — 24 control points used in the exterior orientation

$M_{horizontal}$=1.28m

3. Model 73 field-bund — 25 control points used in the exterior orientation

$M_{horizontal}$=1.22m

4. Model 73 field-bund* — **5** control points used in the exterior orientation

$M_{horizontal}$=2.75m

5. Model 73 well — 4 control points used in the exterior orientation

$M_{horizontal}$=1.08m

6. Model 09 well — 5 control points used in the exterior orientation

$M_{horizontal}$=0.30m

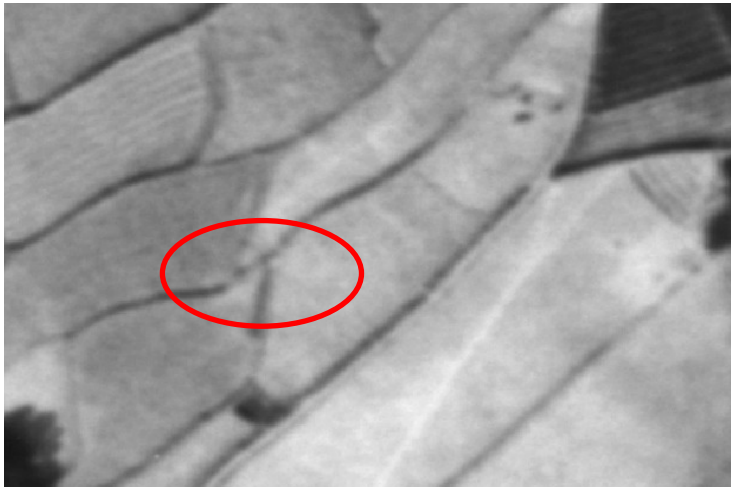
Though the formed DOM and the old survey sheet are at same accuracy level, we still suggest to adopt the DOM as priority reference.

- More reliable than old survey sheet
  (2 Cases will be given)

- have 3D property (better for measurement)

Maps should be used together with photos

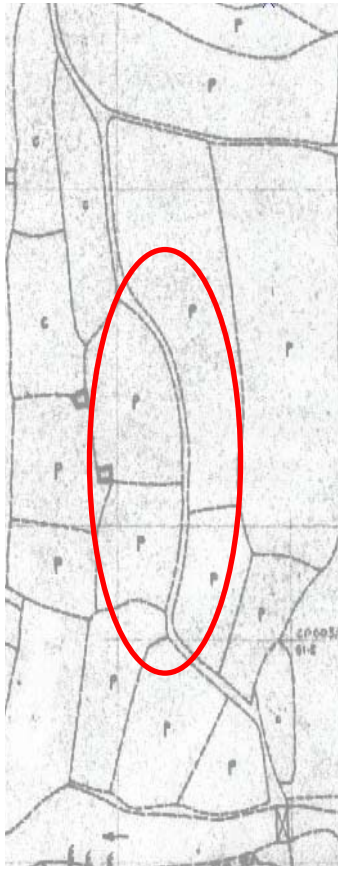
Area in 1960



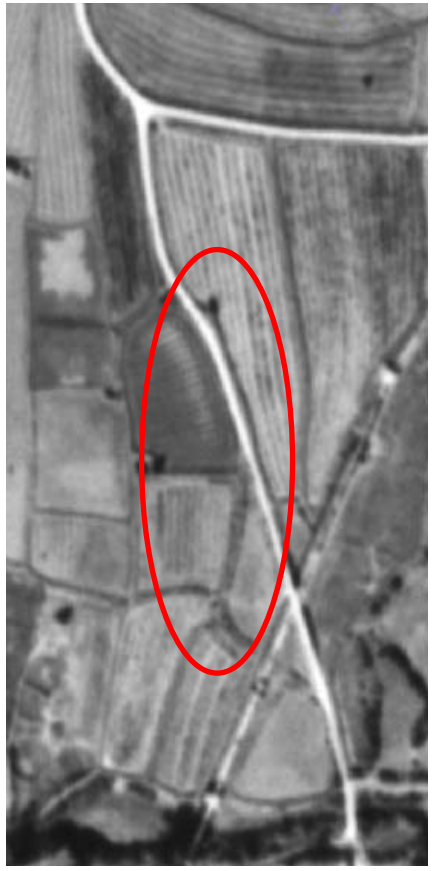
Area in 1963(photo)

Area in 1967 (without update)

Area in 1973 (finally update)

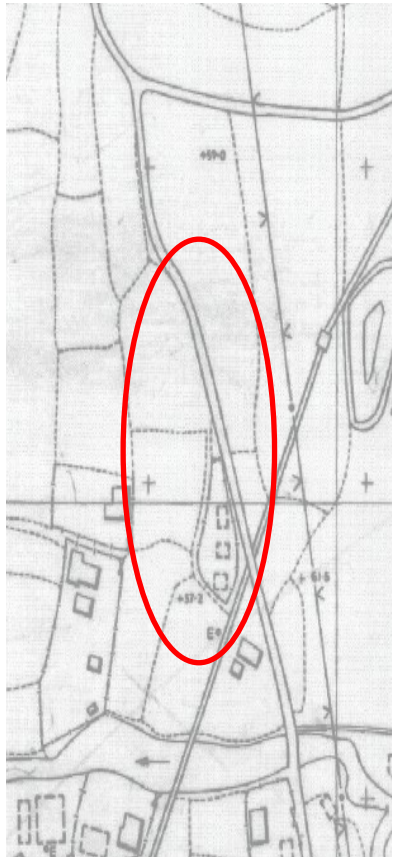


Path in 1960
(curved)



Path in 1963
(straight)

Path in 1967
(curved)



Path in 1973
(straight)

Conclusion

- Precise exterior orientation reference points control the model accuracy

  - Best accuracy achieved – Wells 0.3 m
  - General accuracy using old maps - 1.2 m

Thank You !