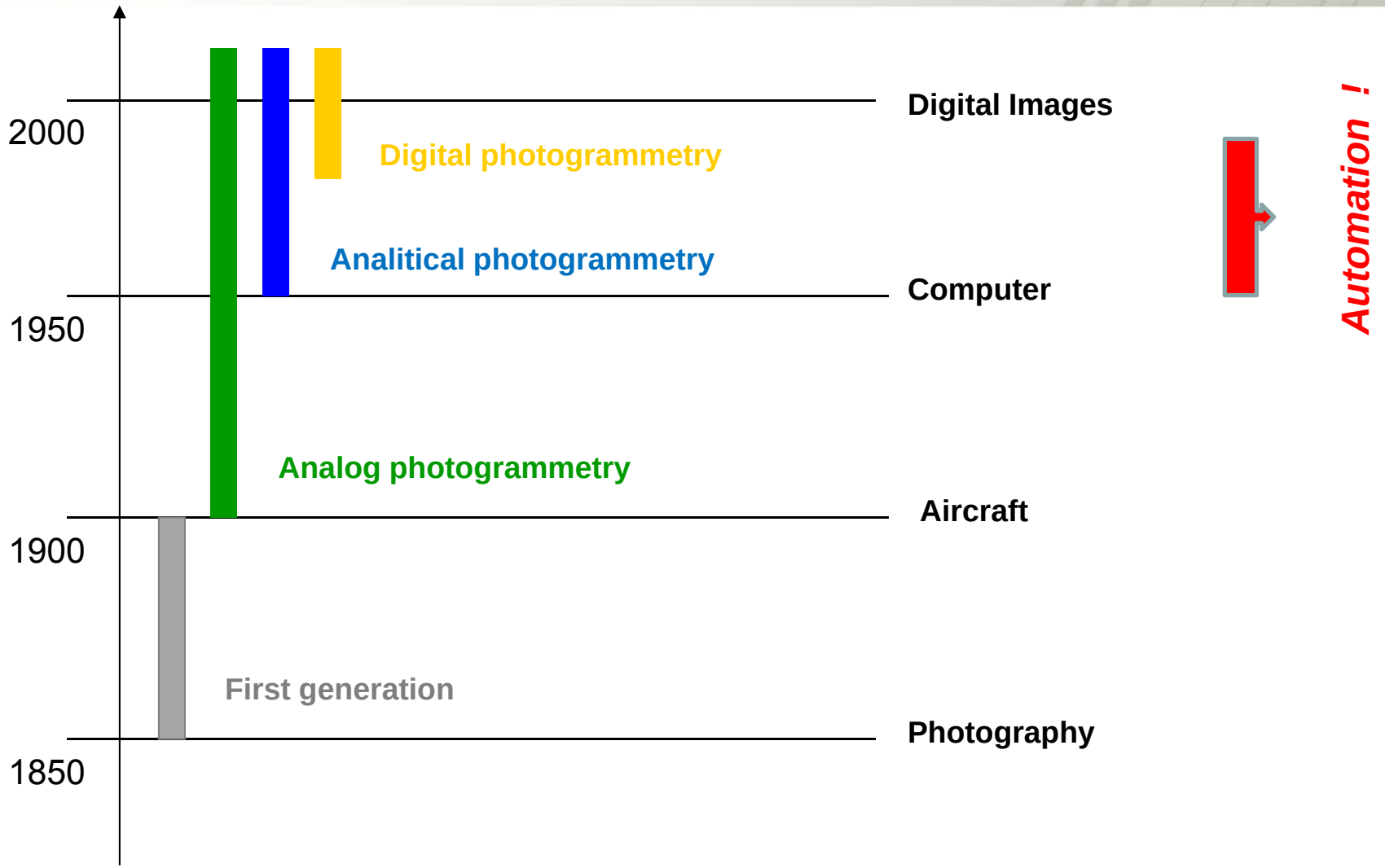
AKADEMIA GÓRNICZO-HUTNICZA
IM. STANISŁAWA STASZICA W KRAKOWIE

Photogrammetry and Remote Sensing

Lecture : Aerotriangulation

dr inż. Sławomir Mikrut

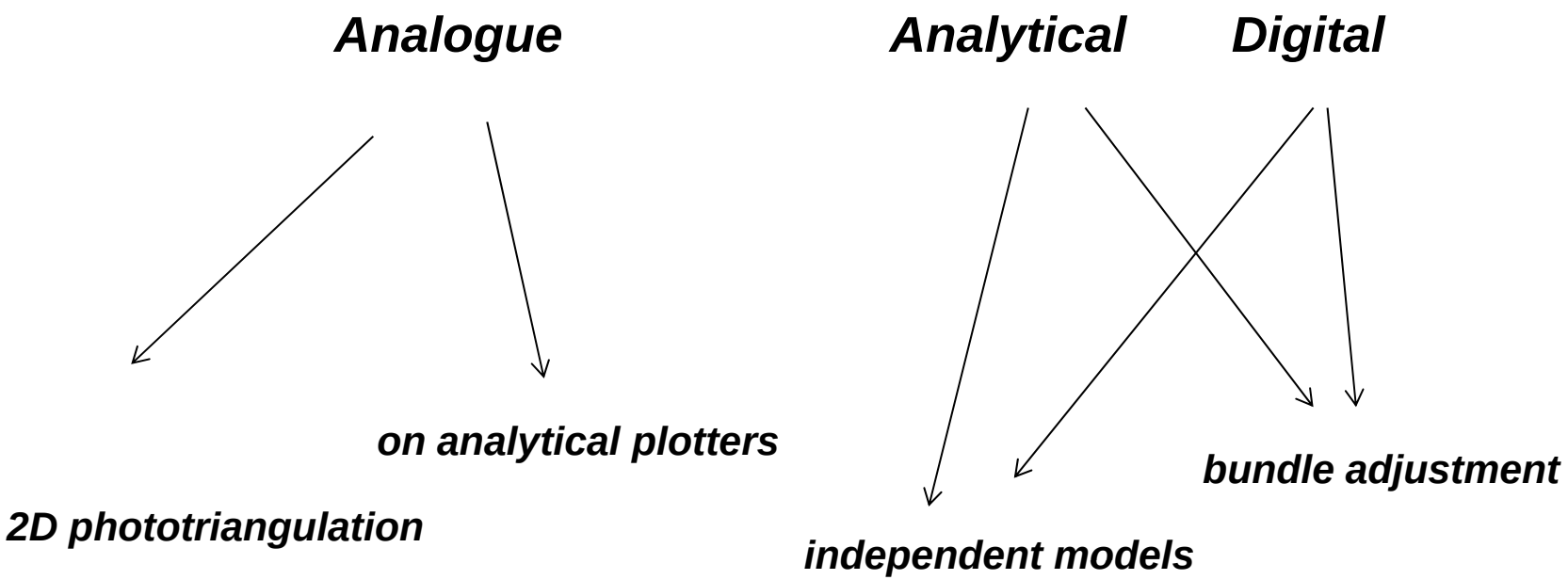
The history …


2000
1950
1900
1850
Digital photogrammetry
Analitical photogrammetry
Analog photogrammetry
First generation
Digital Images
Computer
Aircraft
Photography
Automation !

Aerotriangulation - definition

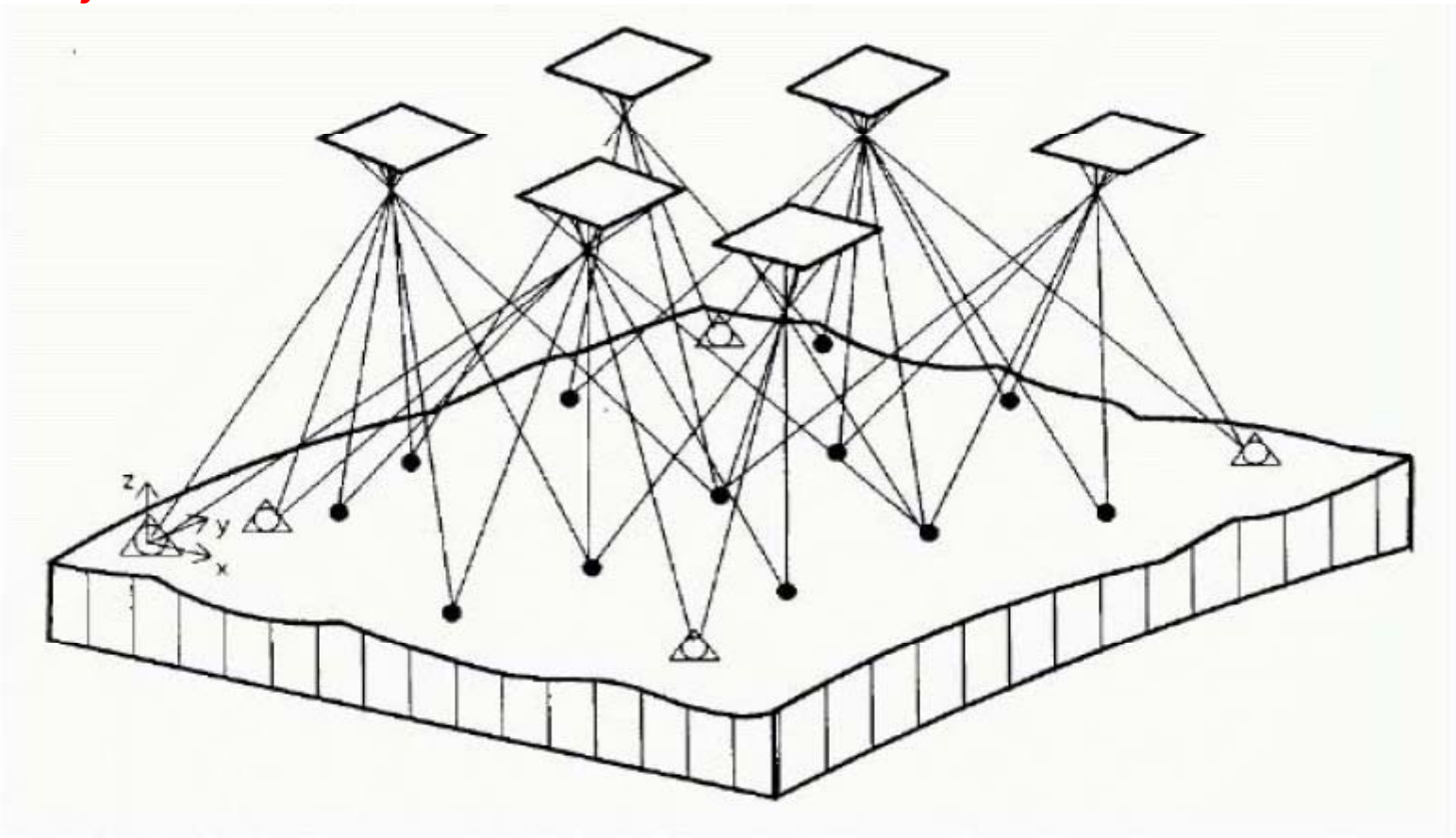
Aerotriangulation - is the process of assigning ground control values to points on a block of photographs by determining the relationship between the photographs and known ground control points.

Aerotriangulation method - division



Aerotriangulation

bundle adjustment method



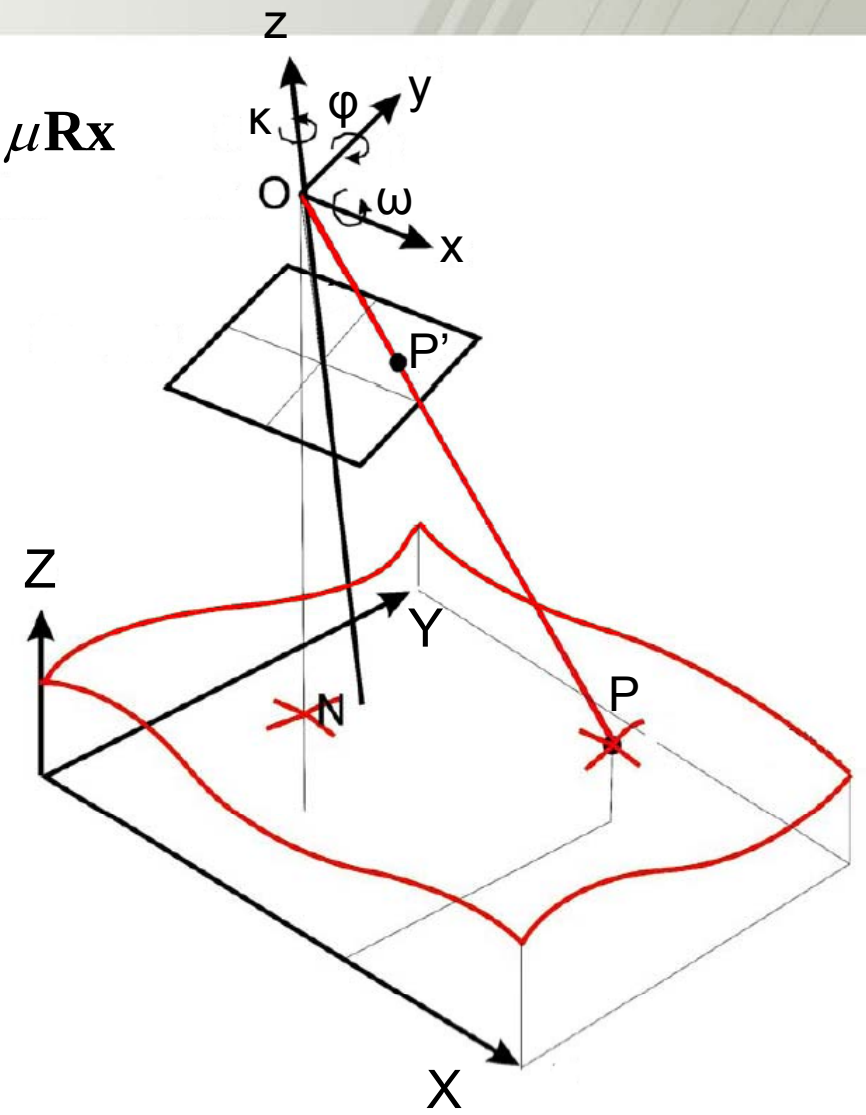
Krystian Pyka, wykłady z "Teledetekcji i fotogrametrii", III r GiK, 2007/2008

Aerotriangulation - background

$$\mathbf{X} = \mathbf{X}_O + \mathbf{X}_{OP} = \mathbf{X}_O + \mu \mathbf{X}_{OP'} = \mathbf{X}_O + \mu \mathbf{R} \mathbf{x}$$

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} X_0 \\ Y_0 \\ Z_0 \end{bmatrix} + \mu \mathbf{R}(\omega, \varphi, \kappa) \begin{bmatrix} x \\ y \\ -c \end{bmatrix}$$

$$\begin{bmatrix} x \\ y \\ -c \end{bmatrix} = \frac{1}{\mu} \mathbf{R}^{\mathbf{T}} \begin{bmatrix} X - X_0 \\ Y - Y_0 \\ Z - Z_0 \end{bmatrix}$$



Aerotriangulation - background

$$\mathbf{X} = \mathbf{X}_O + \mathbf{X}_{OP} = \mathbf{X}_O + \mu \mathbf{X}_{OP'} = \mathbf{X}_O + \mu \mathbf{R} \mathbf{x}$$

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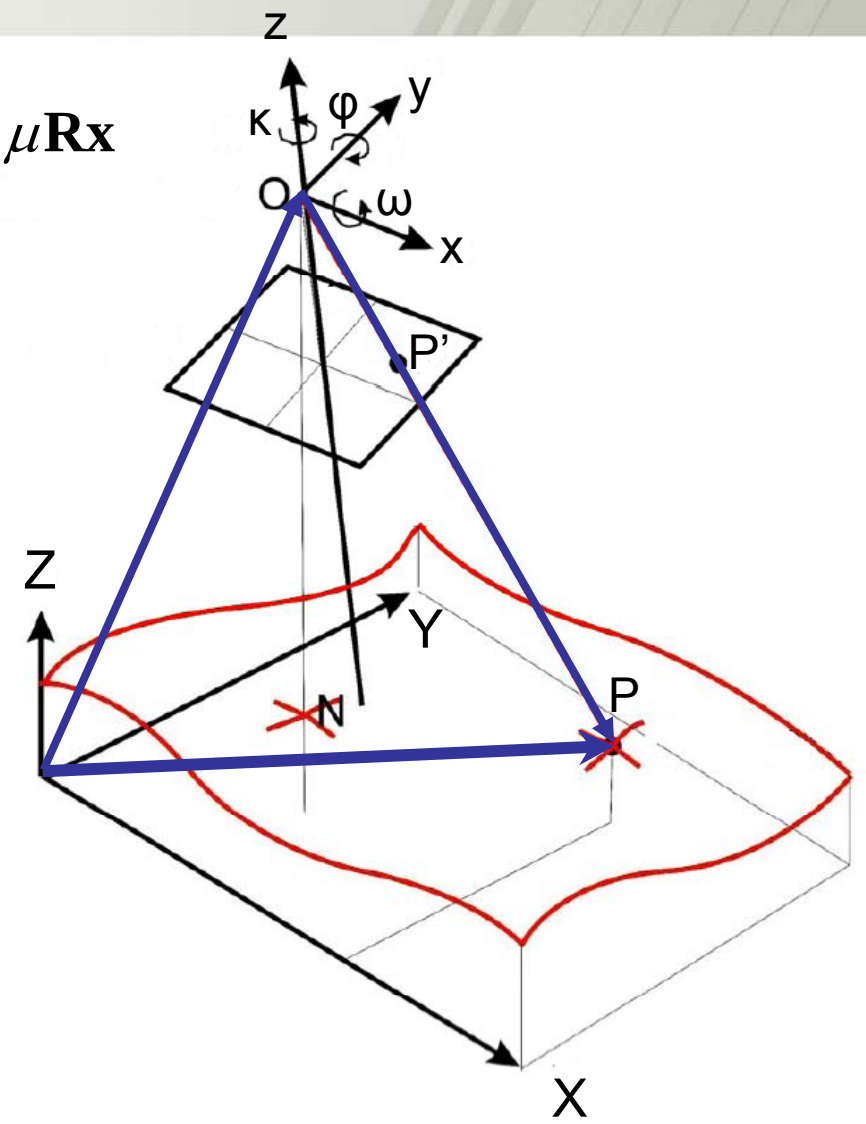


Aerotriangulation - background

$$\begin{bmatrix} x \\ y \\ -c \end{bmatrix} = \frac{1}{\mu}\mathbf{R}^{\mathbf{T}}\begin{bmatrix} X - X_0 \\ Y - Y_0 \\ Z - Z_0 \end{bmatrix}$$

$$x = -c\frac{r_{11}(X - X_O) + r_{21}(Y - Y_O) + r_{31}(Z - Z_O)}{r_{13}(X - X_O) + r_{23}(Y - Y_O) + r_{33}(Z - Z_O)} = -c\frac{L_x}{M}$$

$$y = -c\frac{r_{12}(X - X_O) + r_{22}(Y - Y_O) + r_{32}(Z - Z_O)}{r_{13}(X - X_O) + r_{23}(Y - Y_O) + r_{33}(Z - Z_O)} = -c\frac{L_y}{M}$$

$$x + v_x = f_x(X, Y, Z, X_O, Y_O, Z_O, \varpi, \varphi, \kappa, x_o, dx_o, c, dc, dx)$$

$$y + v_y = f_y(X, Y, Z, X_O, Y_O, Z_O, \varpi, \varphi, \kappa, y_o, dy_o, c, dc, dy)$$

Aerotriangulation - background

$$x + v_x = f_x(X, Y, Z, X_O, Y_O, Z_O, \varpi, \varphi, \kappa, x_o, dx_o, c, dc, dx)$$

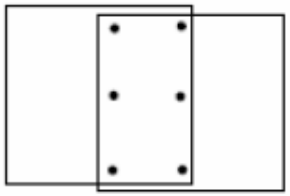
$$y + v_y = f_y(X, Y, Z, X_O, Y_O, Z_O, \varpi, \varphi, \kappa, y_o, dy_o, c, dc, dy)$$

$$v_x = -x + \frac{\partial x}{\partial X} dX + \frac{\partial x}{\partial Y} dY + \frac{\partial x}{\partial Z} dZ + \frac{\partial x}{\partial X_O} dX_O + \frac{\partial x}{\partial Y_O} dY_O + \frac{\partial x}{\partial Z_O} dZ_O + \frac{\partial x}{\partial \varpi} d\varpi + \frac{\partial x}{\partial \varphi} d\varphi + \frac{\partial x}{\partial \kappa} d\kappa + \ldots$$

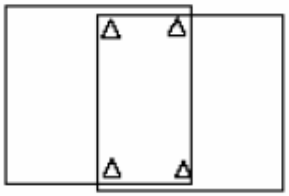
$$v_y = -y + \frac{\partial y}{\partial X} dX + \frac{\partial y}{\partial Y} dY + \frac{\partial y}{\partial Z} dZ + \frac{\partial y}{\partial X_O} dX_O + \frac{\partial y}{\partial Y_O} dY_O + \frac{\partial y}{\partial Z_O} dZ_O + \frac{\partial y}{\partial \varpi} d\varpi + \frac{\partial y}{\partial \varphi} d\varphi + \frac{\partial y}{\partial \kappa} d\kappa + \ldots$$

Aerotriangulation - example

Points to relative orientation

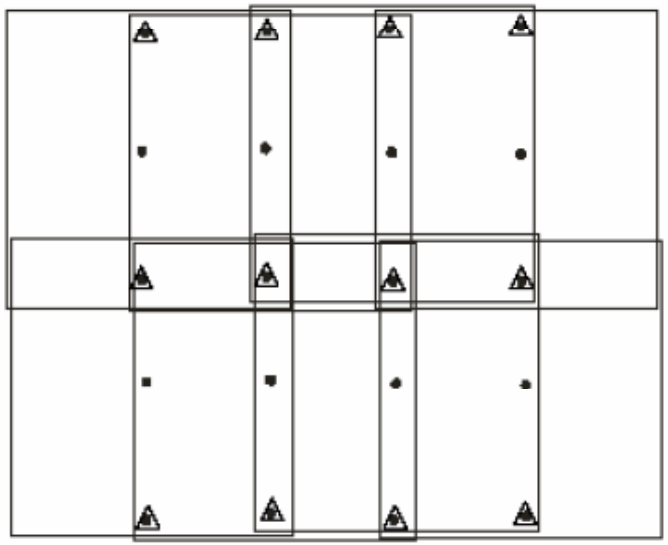


Points to absolute orientation

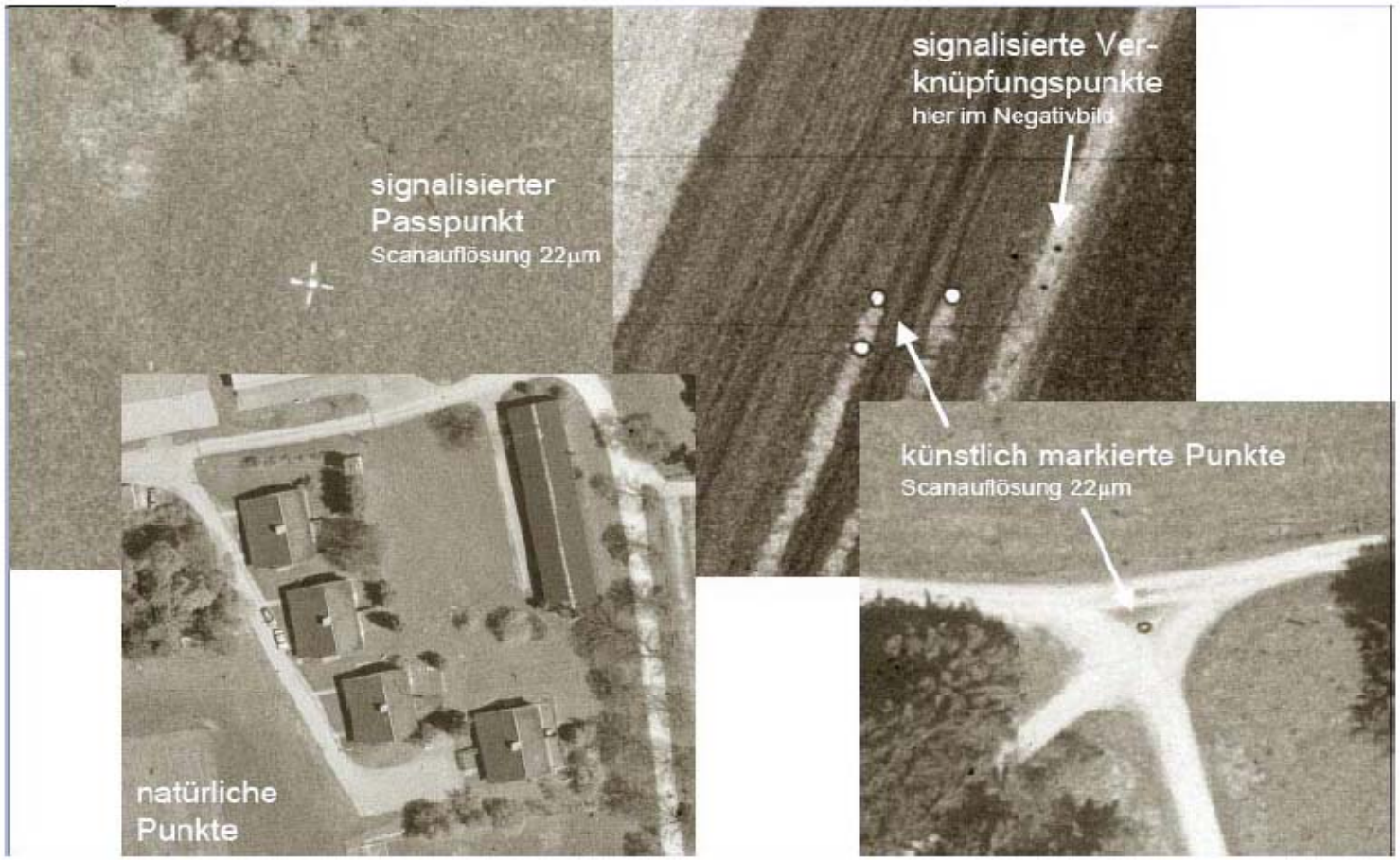


Example of the block:

- 2 strips
- 8 photos
- 20 tie-points and pass points
- 12 GCP's



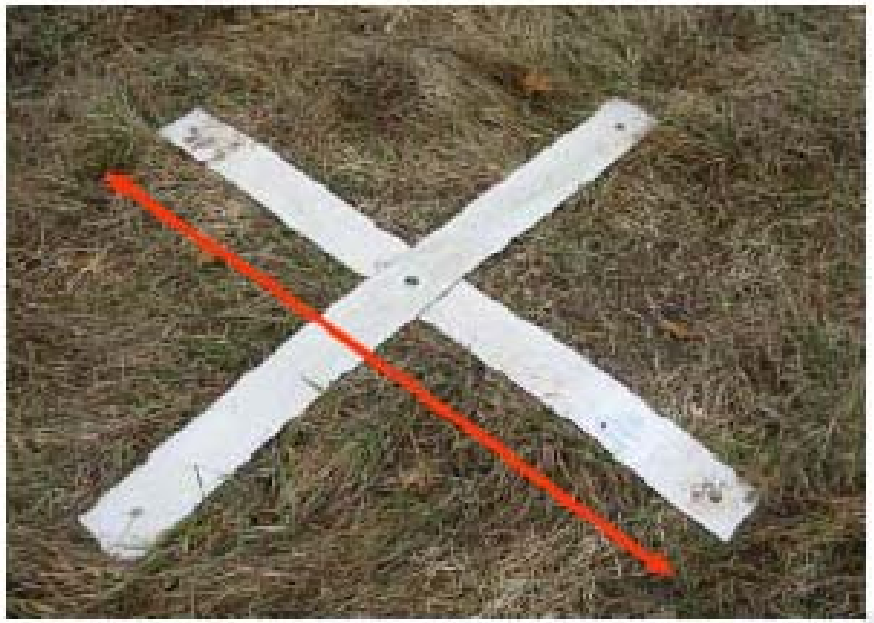
Aerotriangulation - GCP



Krystian Pyka, wykłady z "Teledetekcji i fotogrametrii", III r GiK, 2007/2008

Aerotriangulation - GCP

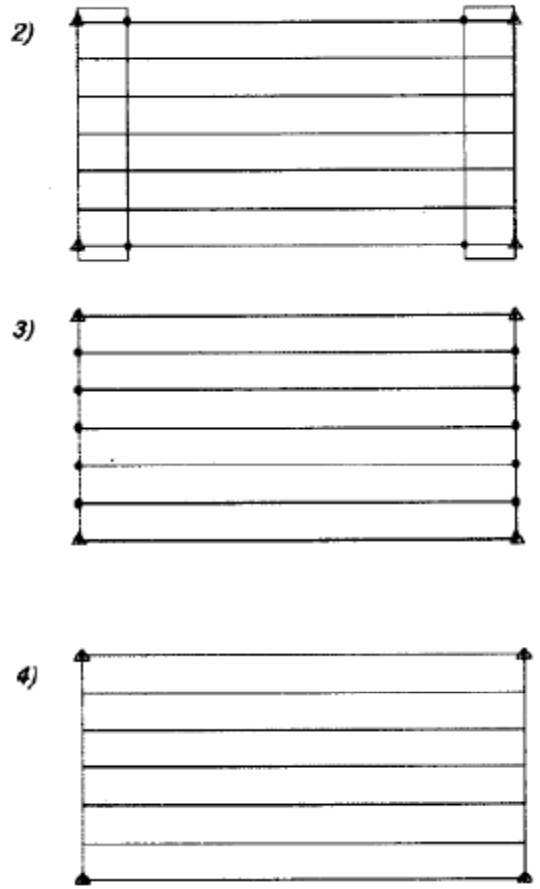
Sygnalisation of GCP - example



Aerotriangulation – with GCP

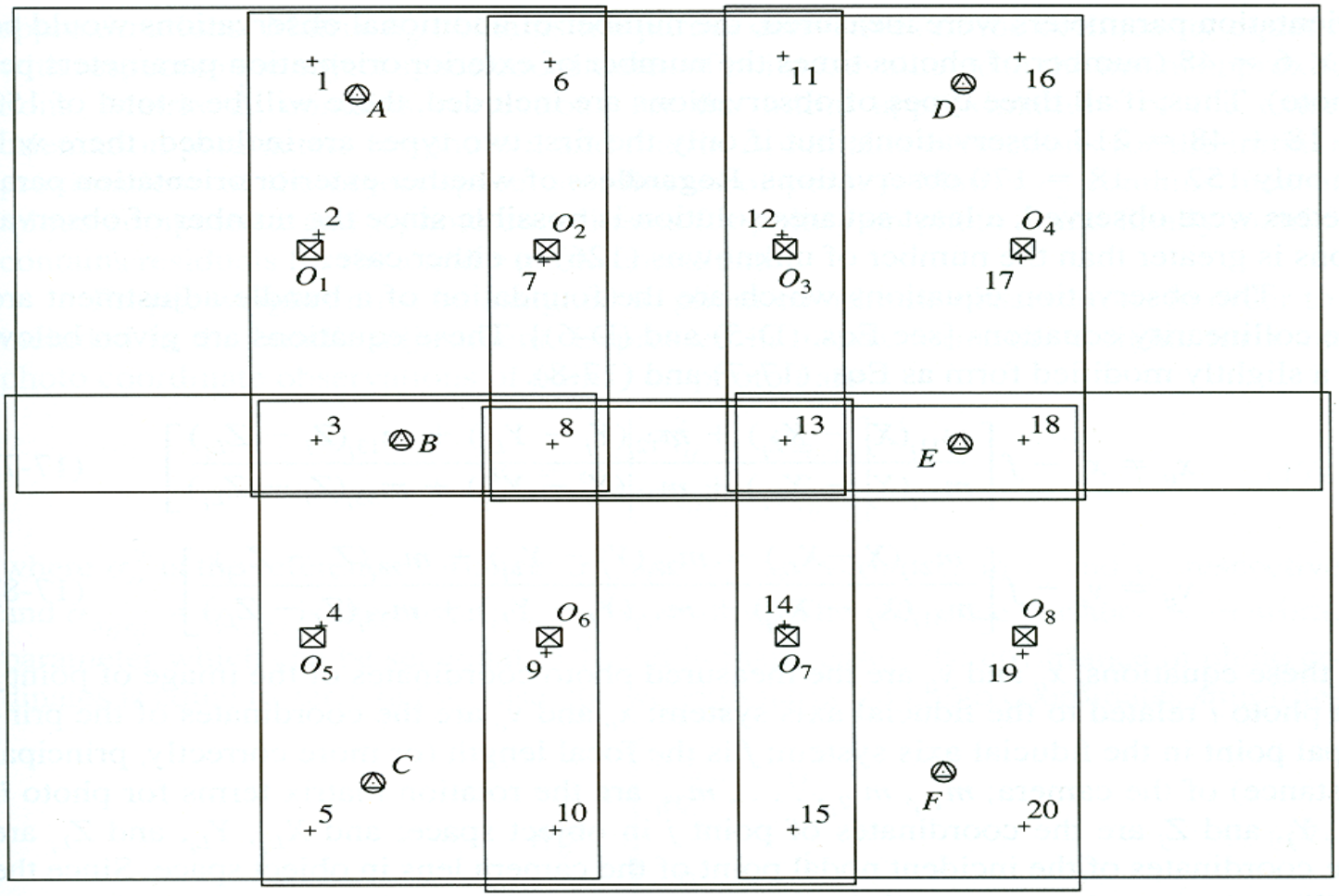
Classical block (without GPS)

With INS/GPS

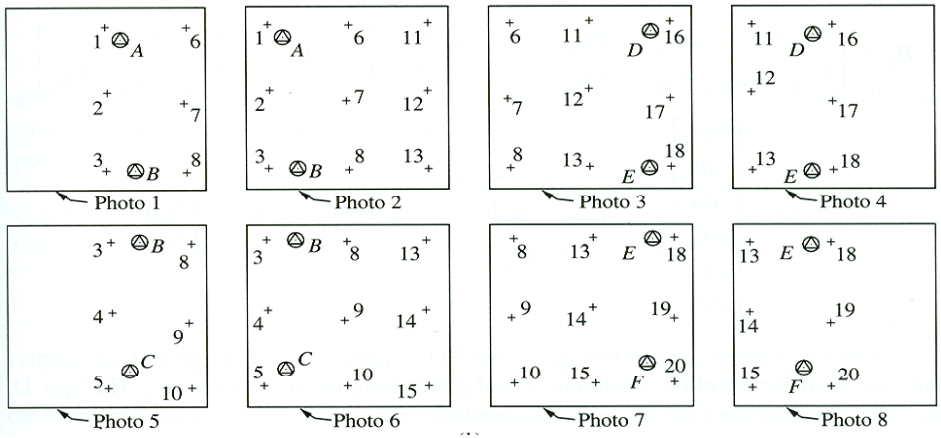


K-2-7 Technical Instruction

Aerotriangulation - example

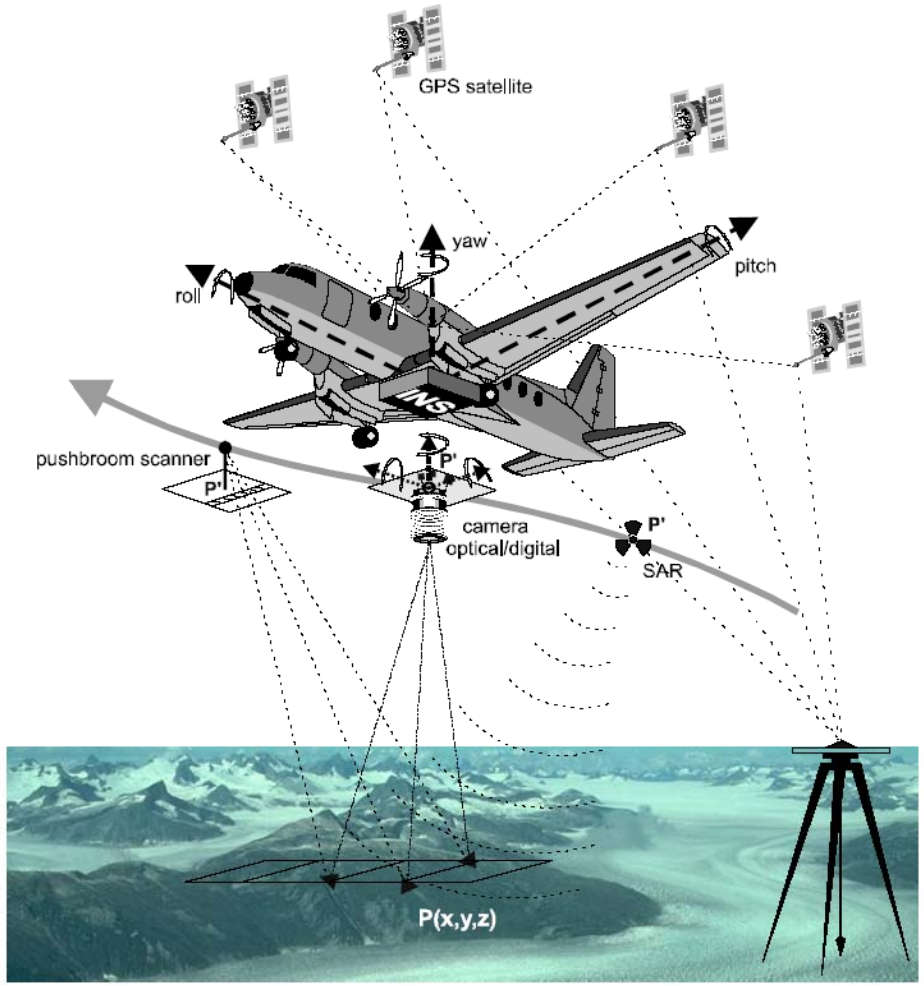


- *Numbers of observation equations*:
  - tie-points : 2 x (6+9+9+6+6+9+9+6) = 2 x 60 = 120
  - GSP: 2 x (2+2+2+2+2+2+2+2) = 2 x 16 = 32
  - Summary: 152
- *Unknows number:*
  - Exterior orientations elements : 6 x 8 = 48;
  - XYZ of tie-points: 20 x 3 = 60
  - Summary:108
- *Numbers of extra observations*: **152 – 108 = 44**



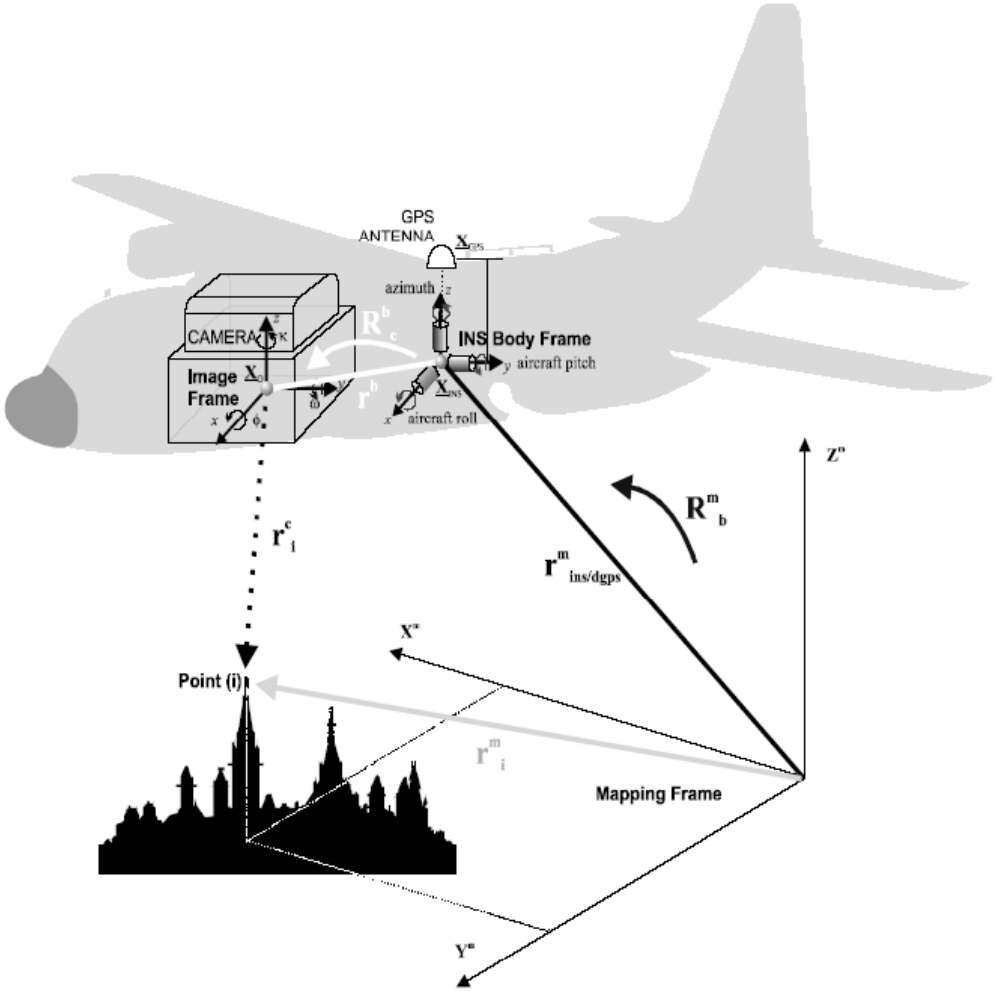
Tie points – *points between photos*
Pass points – *points on strips*

Aerotriangulation - example



Krystian Pyka, wykłady z "Teledetekcji i fotogrametrii", III r GiK, 2007/2008

Aerotriangulation - example



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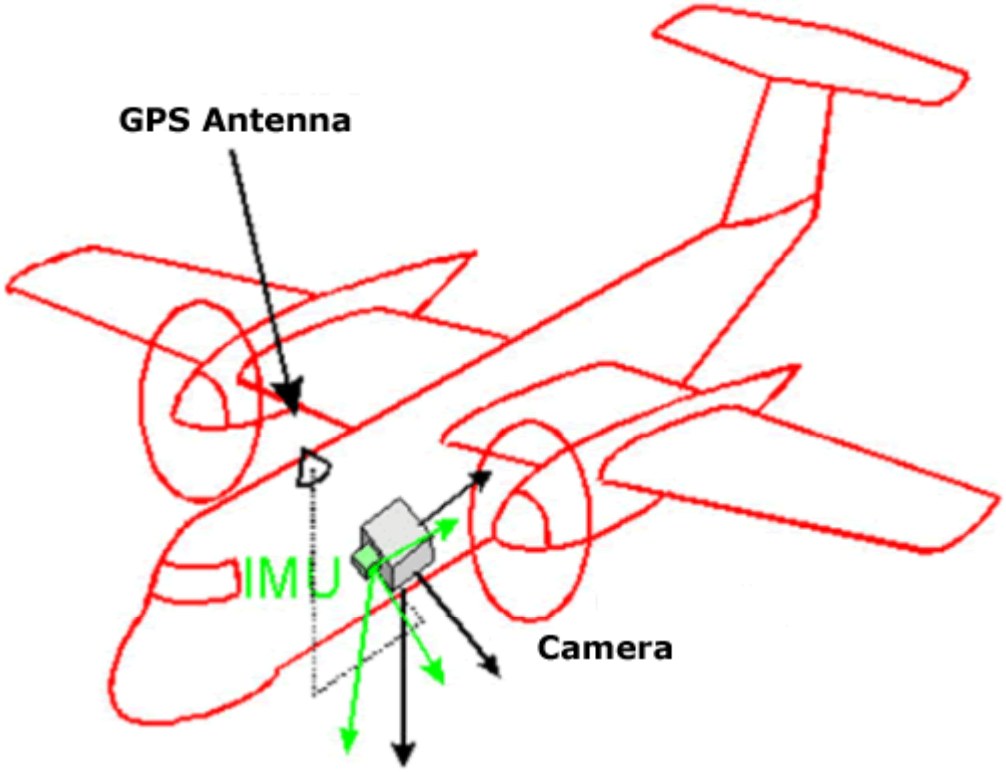
Aerotriangulation - example



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Observation equation with GPS

- *Numbers of observation equations*:
  - tie-points : 2 x (6+9+9+6+6+9+9+6) = 2 x 60 = 120
  - GSP: 2 x (2+2+2+2+2+2+2+2) = 2 x 16 = 32
  - **pespective center 8 x 3 = 24**
  - Summary: 152 **+ 24 = 176**

- *Unknows number:*
  - Exterior orientations elements : 6 x 8 = 48;
  - XYZ of tie-points: 20 x 3 = 60
  - **pespective center errors correction for X,Y,Z shift and drift in every strip: 2 x 2 x 3 = 12**
  - Summary:108 **+ 12 = 120**

- *Numbers of extra observations:* **176 – 120 = 56**

- **Additional advantage:**

- **approximation of XYZ is better defined,**
- **less iteration.**

Observation equation with GPS and INS

- *Numbers of observation equations*:
  - tie-points : 2 x (6+9+9+6+6+9+9+6) = 2 x 60 = 120
  - GSP: 2 x (2+2+2+2+2+2+2+2) = 2 x 16 = 32
  - **pespective center 8 x 3 = 24**
  - **Angles HPR: 8 x 3 = 24**
  - Summary: 152 **+ 24 + 24 = 200**

- *Unknows number:*
  - Exterior orientations elements : 6 x 8 = 48;
  - XYZ of tie-points: 20 x 3 = 60
  - **pespective center errors correction for X,Y,Z shift and drift in every strip: 2 x 2 x 3 = 12**
  - **Angles HPR correction: 2 x 2 x 3 = 1 2**
  - Summary:108 **+ 12 + 12 = 132**

- *Numbers of extra observations:* **200 – 132 = 68**

- **Additional advantage:**

- **approximation of XYZ is better defined,**
- **approximation of HPR is better defined,**
- **block can be not regular**
- **less iteration.**

Aerotriangulation - software

Inside Photogrammetric Station:

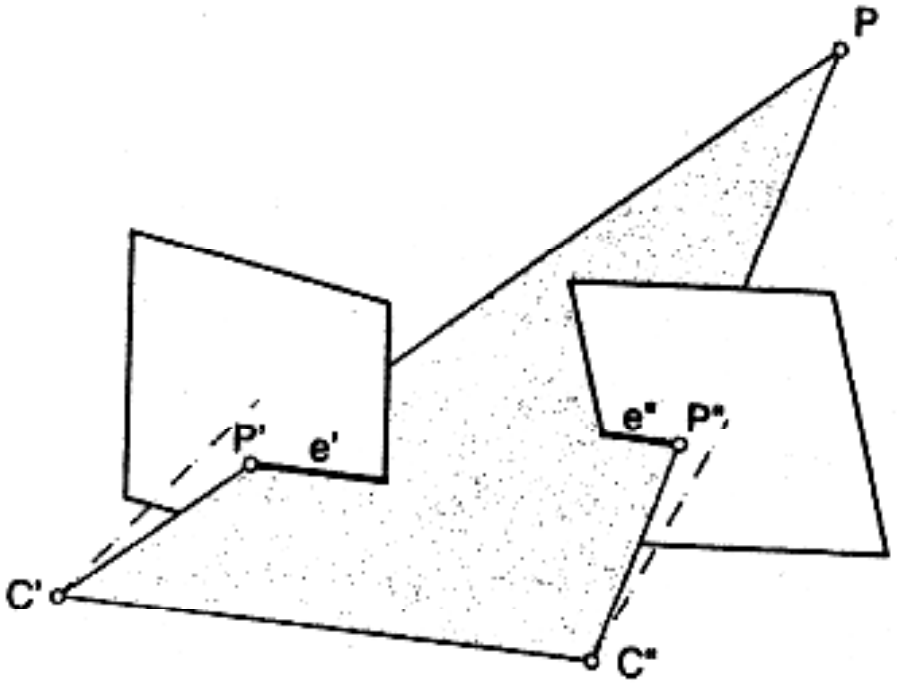
- Image Station
- INPHO
- PCI Geomatica

External:

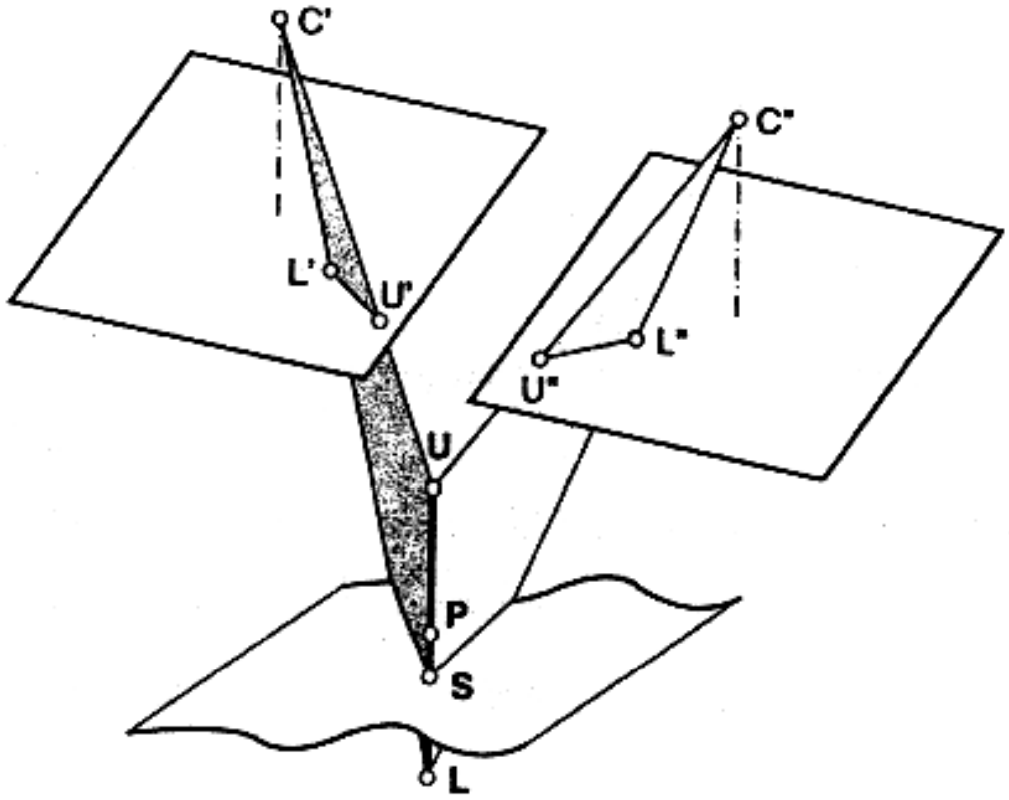
- Bingo
- Pat B/M

Aerotriangulation
– automation of measurement

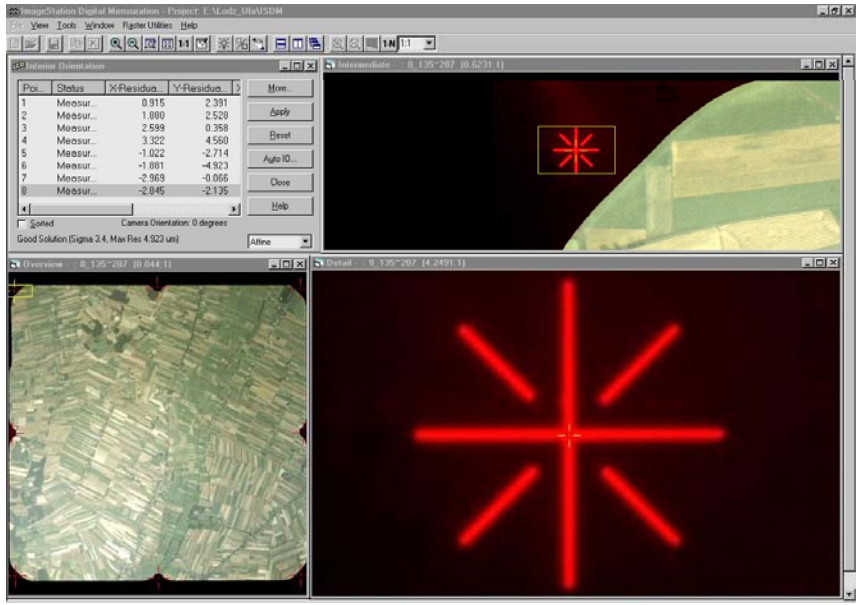
Epipolar line

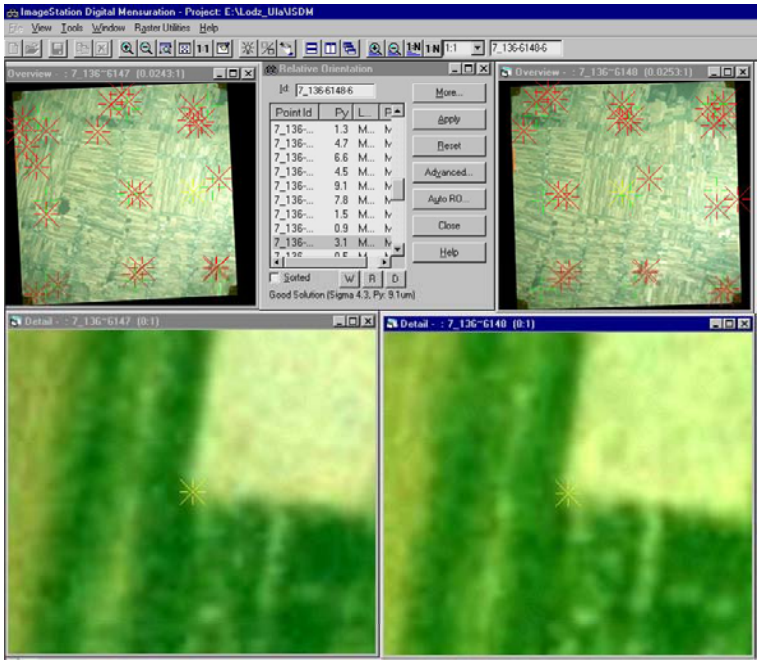


VLL (ang. Vertical Line Locus)

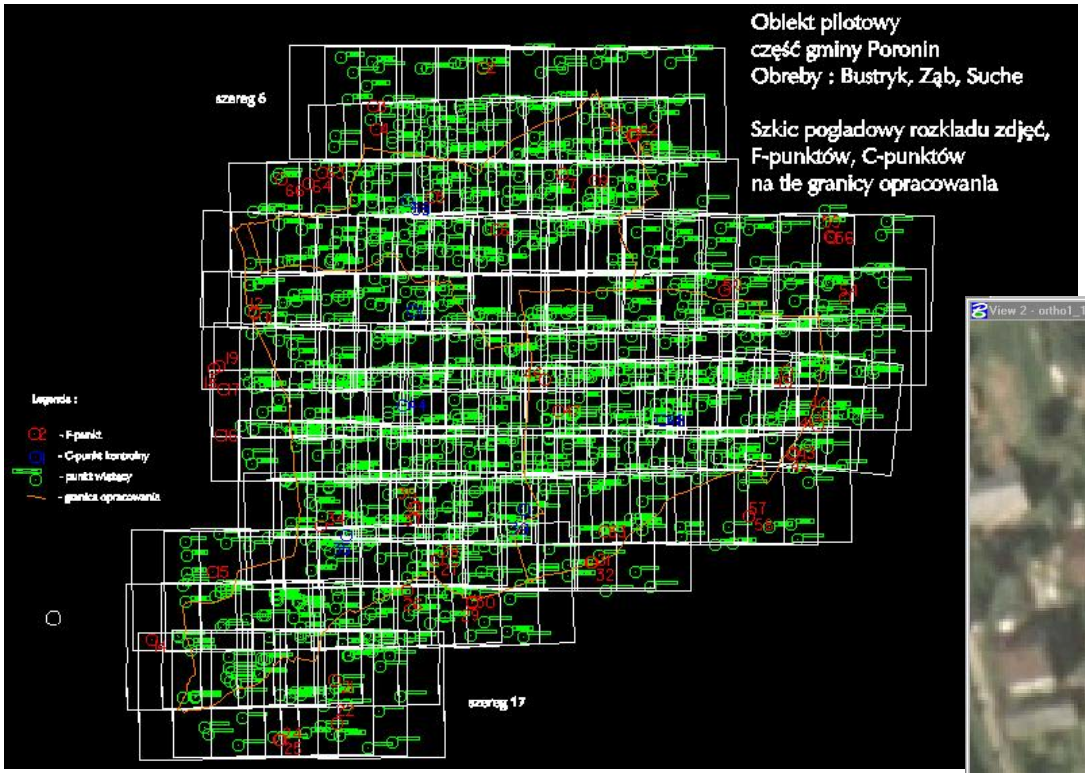


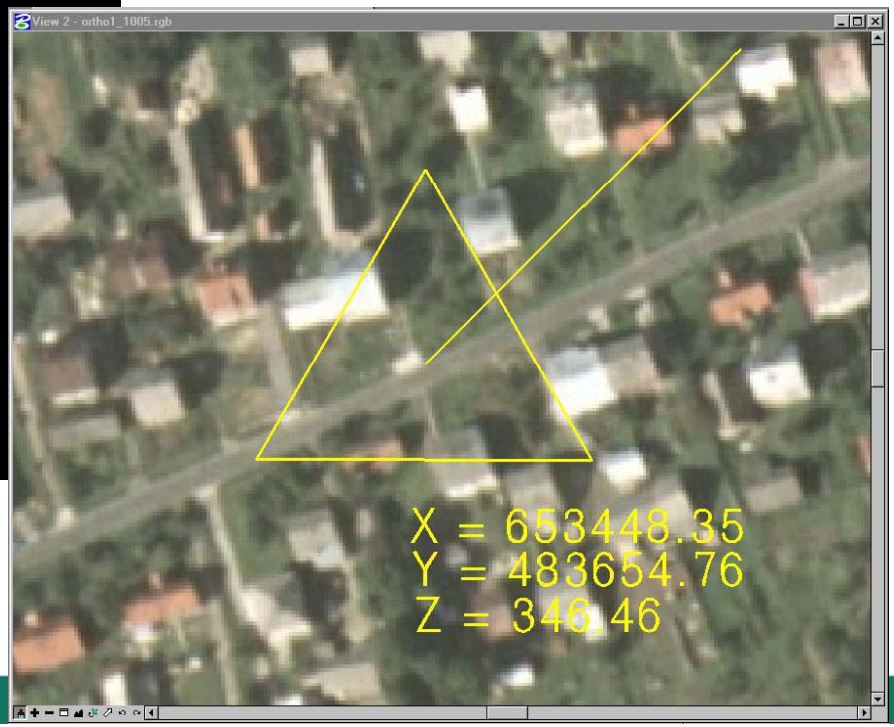
Aerotriangulation - software





Aerotriangulation - software





Aerotriangulation - software

Aerotriangulation
Example of the project – TPN

Data of the project

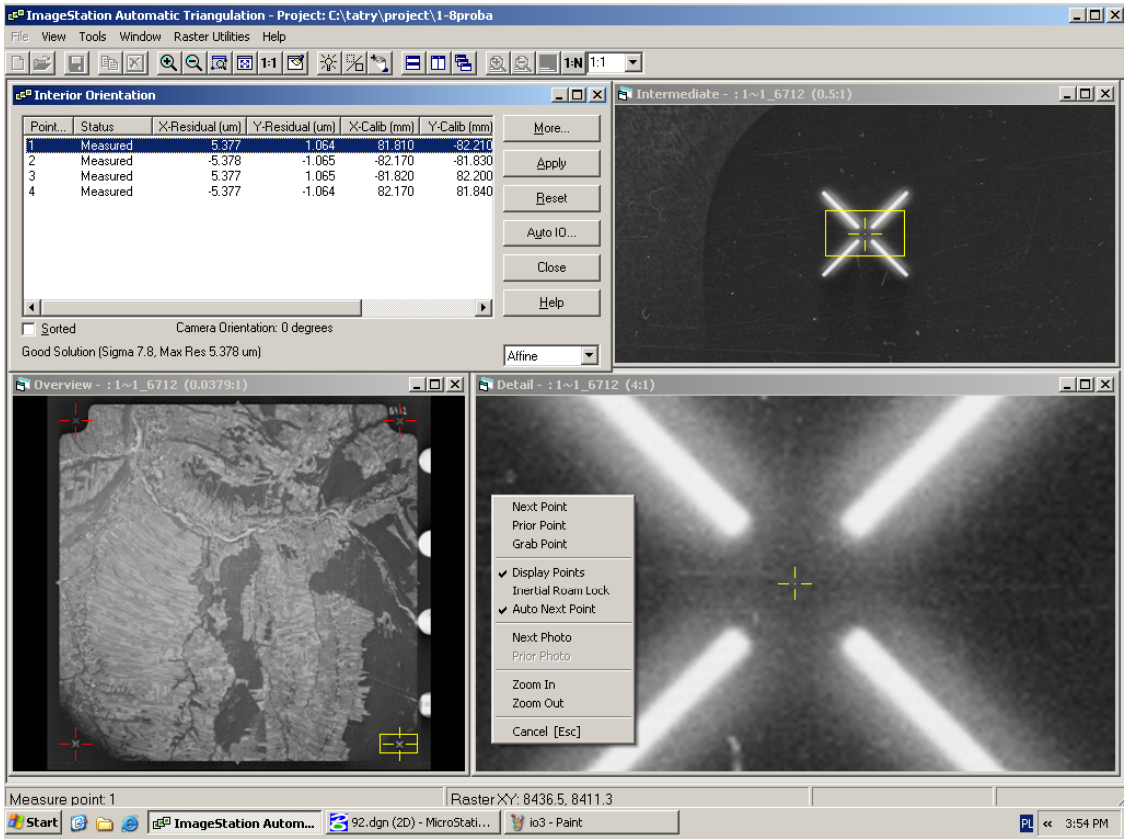
- 74 images TPN from 1974 in scale 1:10000, format 180x180mm, scanned with 21 μm;
- Hight of the fligt – 2550m n.p.m.;
- High of the terrain – 1400m n.p.m.;
- Coordinates in UTM (łącznie 63):

Definition of the project

Images
Coordinates
Data of the flight
Automatyzacja numeracji punktów wiążących
Definition of the camera
Definition of the strips
Definition of the model
Import GCP coordinates

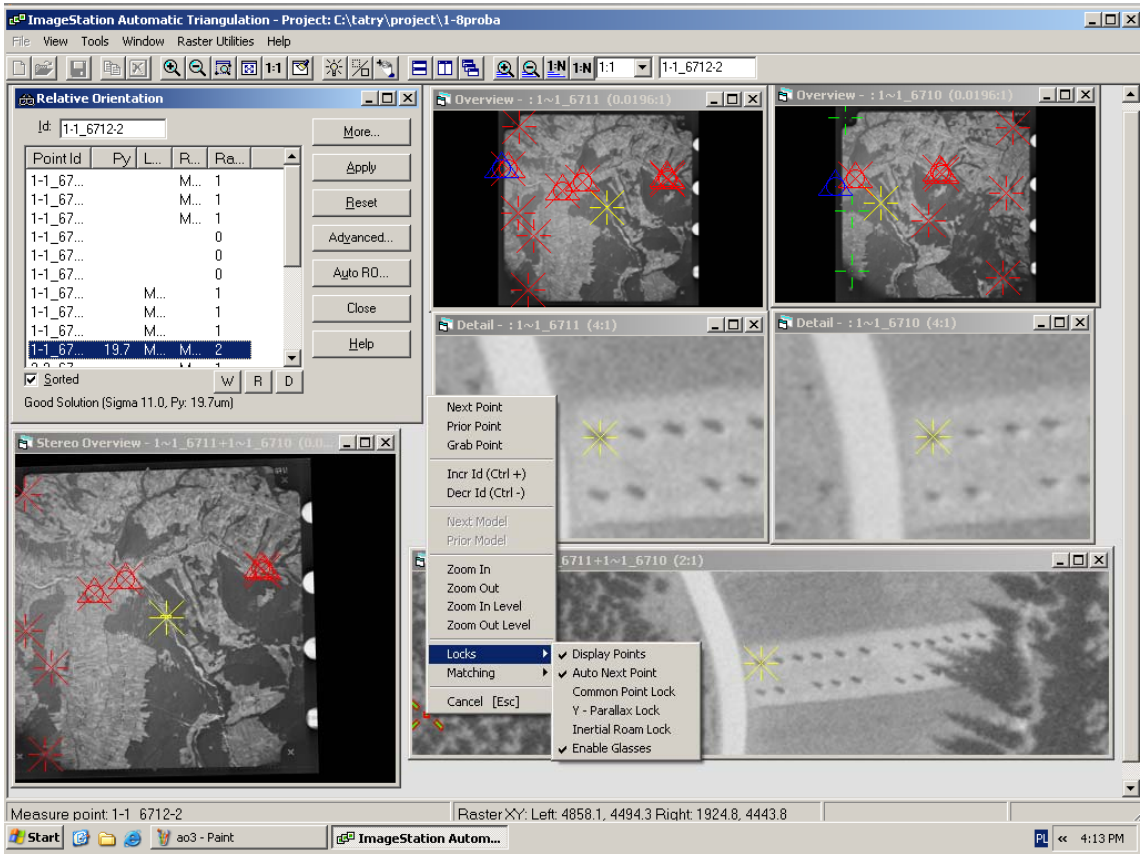
Steps of aerotriangulation

1) Interior orientation



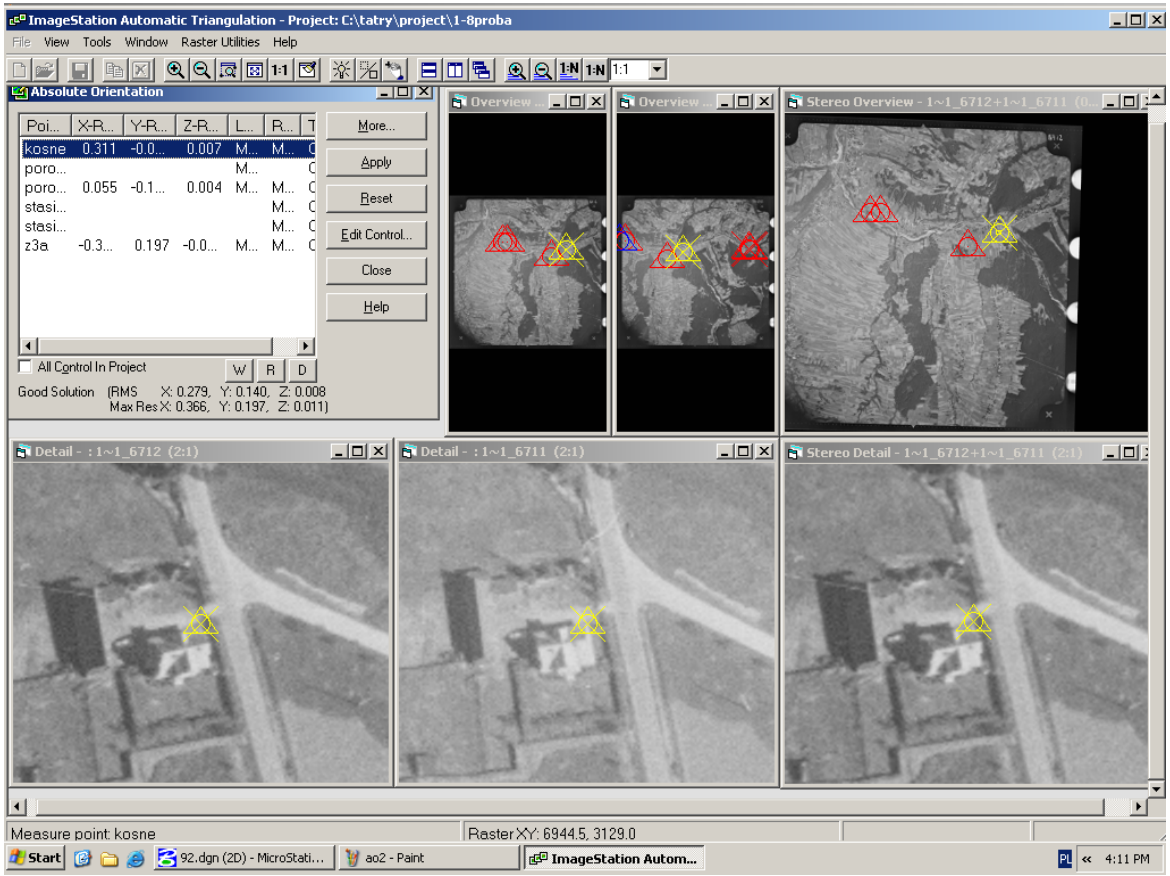
Steps of aerotriangulation

2) Relative orientation



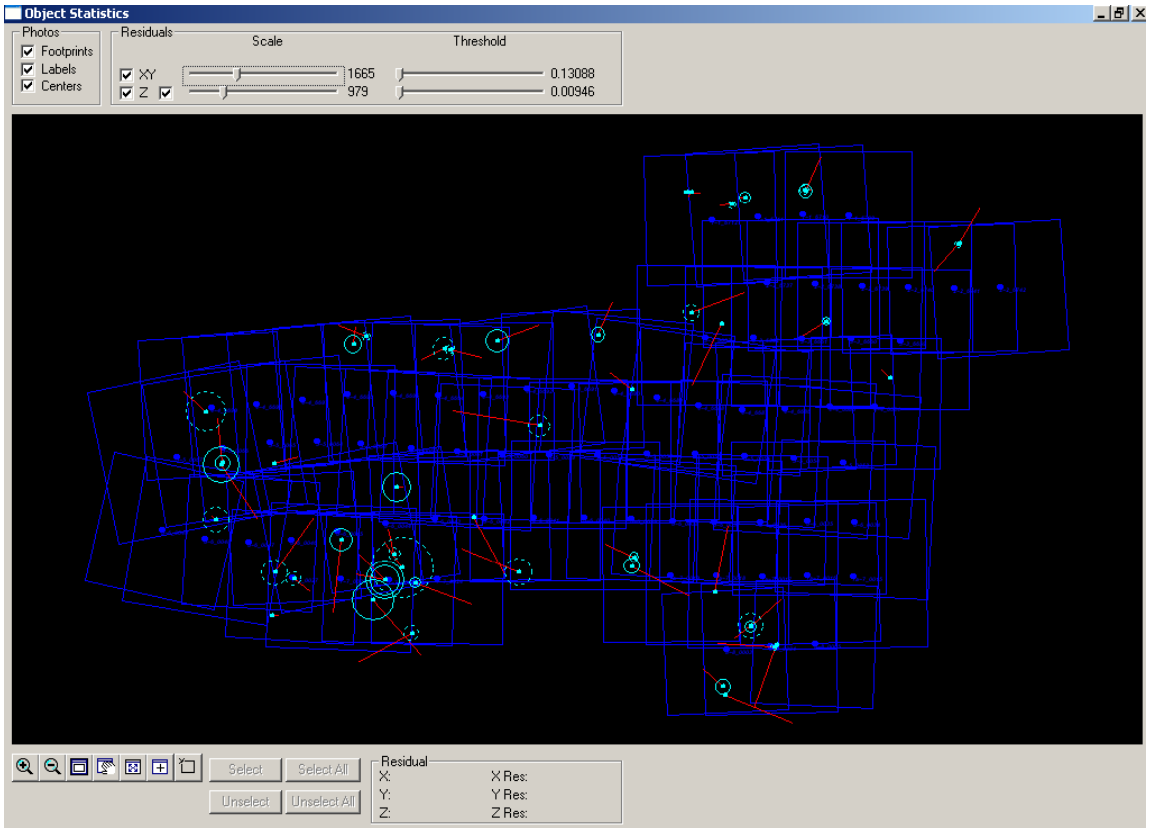
Steps of aerotriangulation

3) Absolute Orientation



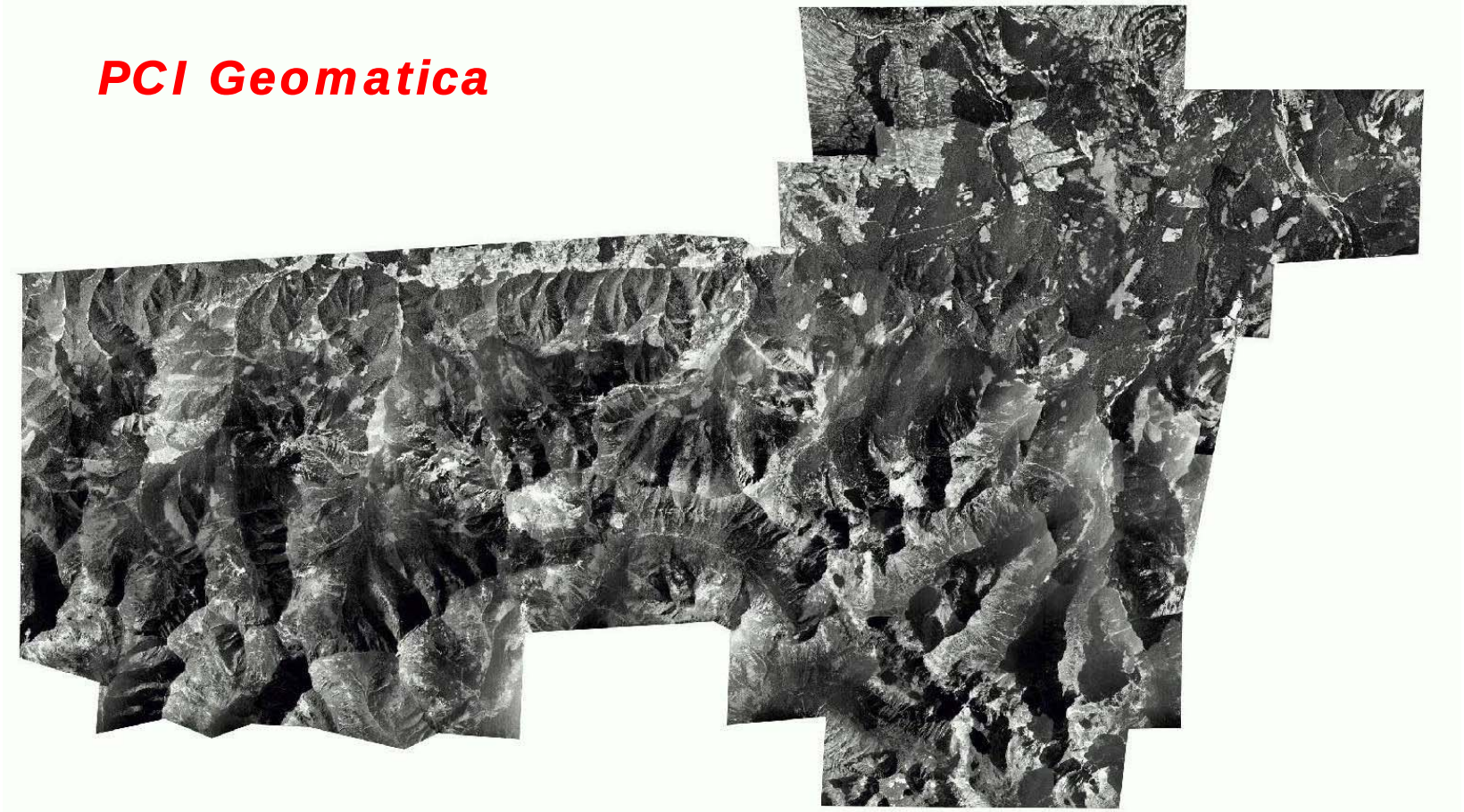
Steps of aerotriangulation

Footprints with errors



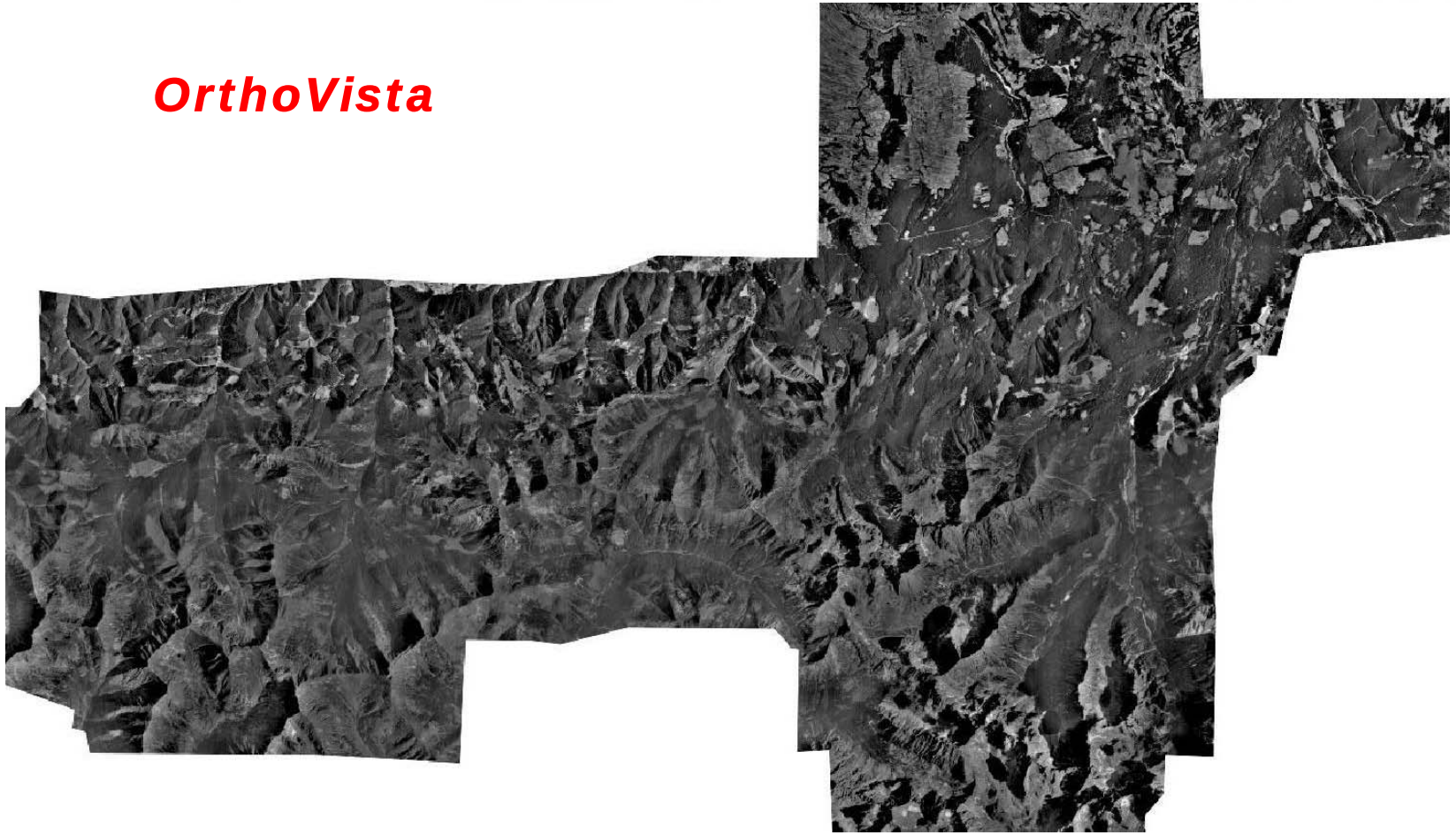
Ortophotomaps

PCI Geomatica



Orthophotomaps

OrthoVista



Thank you for your attention !