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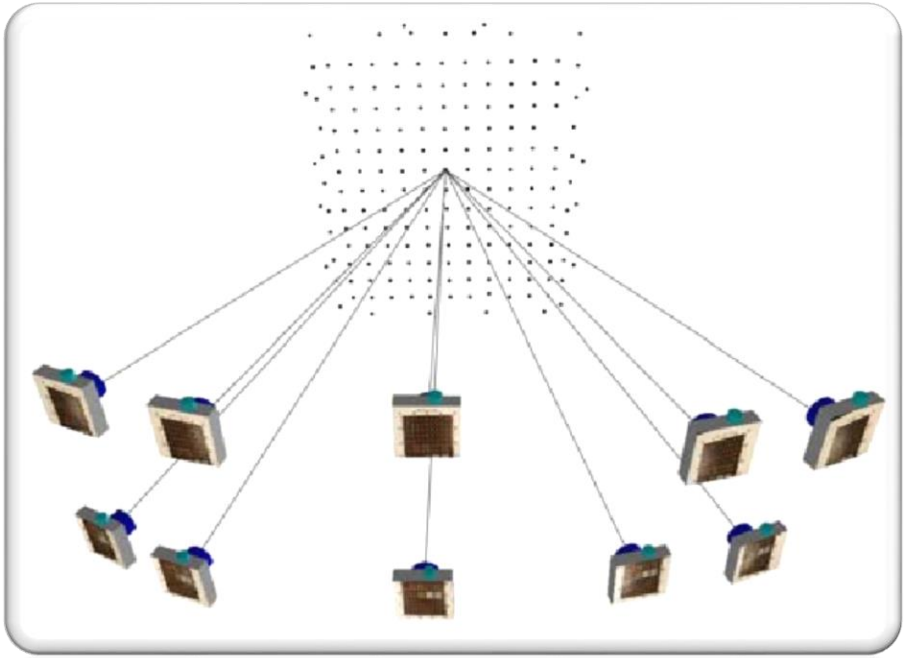
COLLEGE OF ENGINEERING
DEPARTMENT OF SURVEYING ENG.



Close-Range Photogrammetry- Project Workflow

BSc - 4th Stage

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Lecture 3

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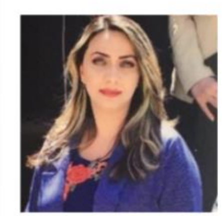


Four Basic Steps of a CRP Project

- The following workflow provides an overview of the steps involved in a close range photogrammetry project.
- Not all close-range photogrammetry projects are the same, but virtually all will include some form of the steps outlines below.

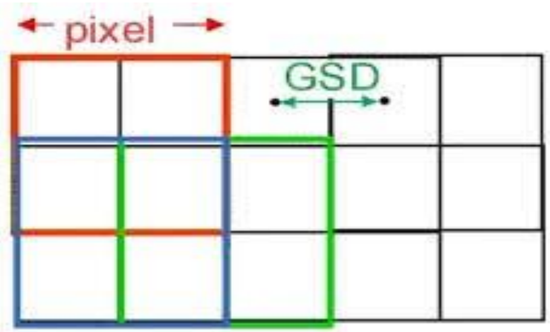
1: Project Planning

Project planning includes a number of important considerations that will influence the success of the project. These include

- Developing a strategy for the site/object
- Selecting the equipment and software to be used
- Calibrating equipment if needed
- Obtaining any required permissions
- Starting the application process.

GSD and Pixel Size

- The Ground Sampling Distance (GSD) is the distance between two consecutive pixel centers measured on the ground. The bigger the value of the image GSD, the lower the spatial resolution of the image and the less visible details. The GSD is related to the Depth "height" "Y average" (the distance between the sensor and the ground object) in CRP: the higher the depth, the bigger the GSD value.



pixel size=	**Sensor size / No. of pixels**

$$Depth = \frac{GSD * f}{pixel}$$

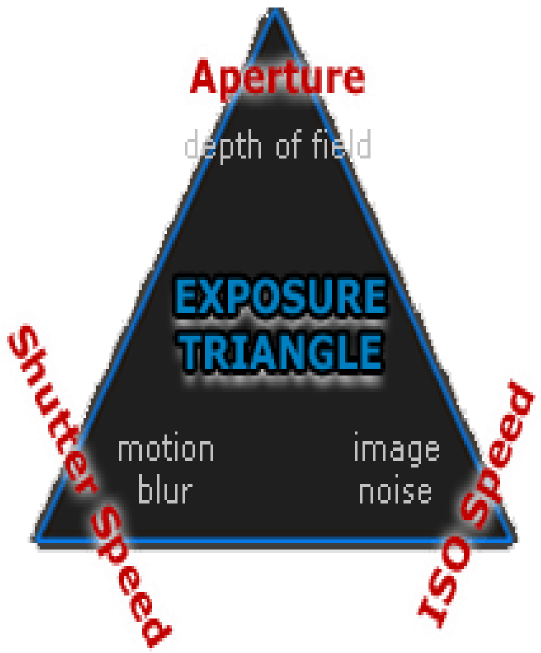
B/H (B/D) setting in CRP

EXPOSURE TRIANGLE: APERTURE, ISO & SHUTTER SPEED

Each setting controls exposure differently:

- **Aperture**: controls the area over which light can enter your camera
- **Shutter speed**: controls the duration of the exposure
- **ISO speed**: controls the sensitivity of your camera's sensor to a given amount of light

One can therefore use many combinations of the above three settings to achieve the same exposure. The key, however, is knowing which trade-offs to make, since each setting also influences other image properties. For example, aperture affects depth of field, shutter speed affects motion blur and ISO speed affects image noise.



2: Image and control acquisition

There are a number of strategies for the collection of images in a photogrammetric project. Typically, the strategy is driven by the software used to process the images, and, more specifically, whether the type of processing requires a stereo or convergent (see figure below) set of images. This topic should be covered in the help file or manual for the software you plan to use.

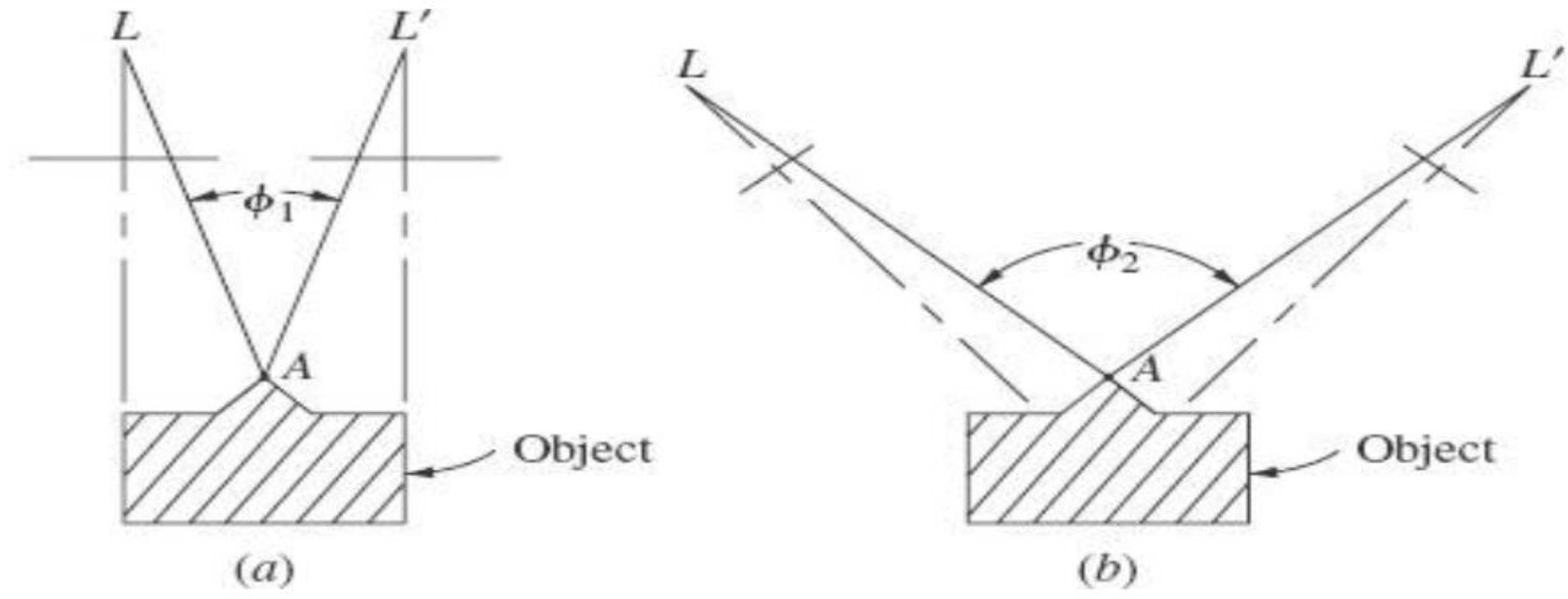


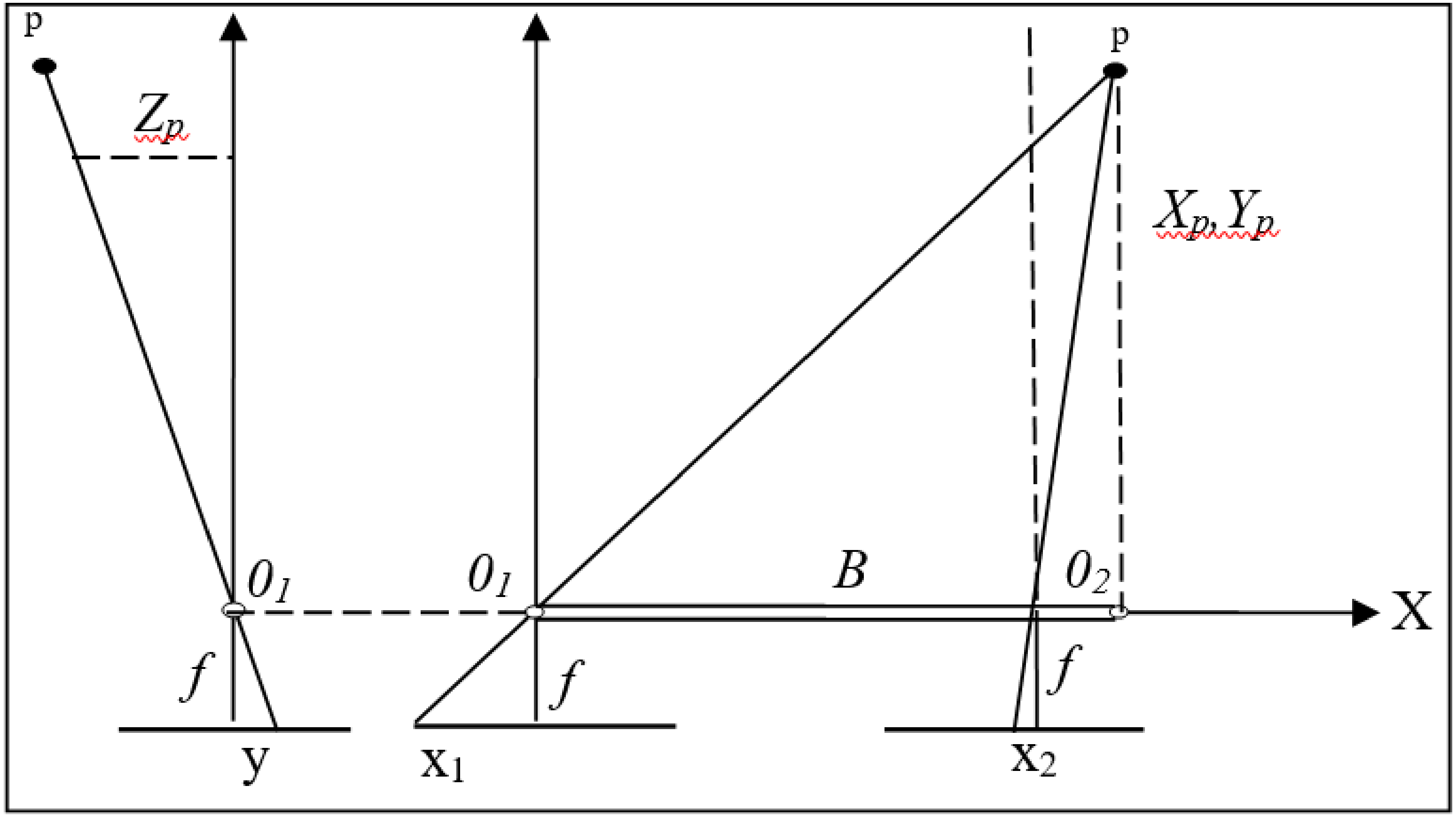
Image acquisition strategies

It can be broadly divided into two main strategies:

- Acquiring data from the object to be measured by taking convergent necessary photographs (oblique case).
- Reducing the photographs (perspective projection) into maps or spatial coordinates (orthogonal/horizontal case).

*Horizontal case is not always technically practical!

Stereo (Horizontal) Strategy



Stereo (Horizontal) Strategy

- Camera axes are parallel to each others.
- Camera axes are perpendicular to base line (B).
- 3D object coordinates can be estimated as follow:

$$Y = \frac{B \times f}{p}$$

$$X = \frac{Y}{f} x$$

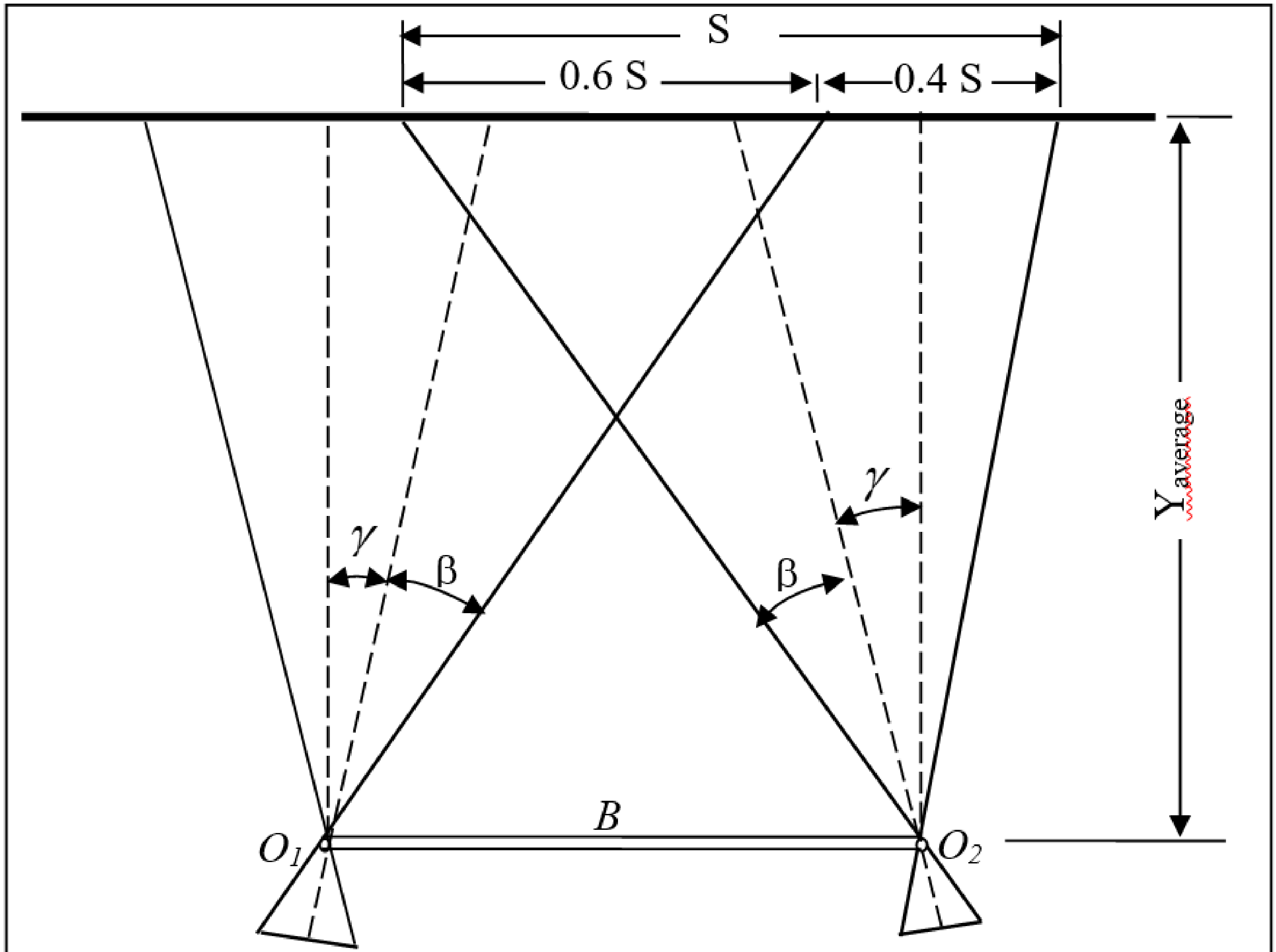
$$Z = \frac{Y}{f} y$$

where:

p: x-parallax

f: camera focal length

Convergent (Oblique) Strategy



Convergent (Oblique) Strategy

- Incline the camera axis somewhat in order to center the object of interest in the field of view.
- The camera axis inclined with a “depression or elevation angle or inclination angle”
- Cameras axes are NOT parallel to each others.
- Cameras axes are NOT perpendicular to base line (B).

Convergent (Oblique) Strategy

- In oblique case, base line (B) can be computed as follow:

$$B = Y_{av}[1.4\tan(\beta + \gamma) - 0.6\tan(\beta - \gamma)]$$

- Where:

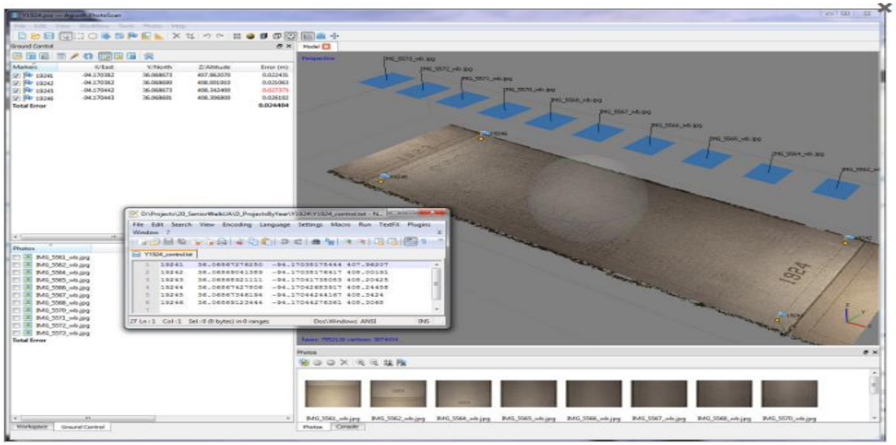
- β : represnts half of the ground coverage (angular measure)
- γ : *inclined angle of the camera axis* from nadir
- Y_{av}: *orthogonal distance between camera and object*

2: Image and control acquisition

External control information can be added to a photogrammetric project for two reasons:

1) to position the model relative to a datum and/or
2) to provide geometric constraints on the photogrammetrically derived model.

If the photogrammetric model is to be situated partially or wholly within an existing reference frame or datum (geodetic, mapping or local) then sufficient external references defined in this frame must be integrated into the project. A 3D reference frame or datum is defined by scale, position and orientation. Typically, reference information is in the form of control points (photo-identifiable points with known coordinates in a reference frame), lengths of photo-identifiable objects, and/or angles between photo identifiable objects



Adding Control Points in PhotoScan Pro (the control points are the four small blue flags with a yellow dot)

2: Image and control acquisition

The minimum amount of information needed to scale, position and orient a photogrammetric model is two 3D control points and one 1D control point. If more than minimal control is provided (e.g. three or more 3D control points) then the control information could be used to help define the shape of the photogrammetric model as well as define its datum.
In this case, the surveyor must ensure that the control information is, as a rule-of-thumb, at least 3x more accurate than the photogrammetric model itself. If it is not, then the control information will distort the photogrammetric model and potentially have deleterious effects on its relative accuracy.

It is also possible to apply control after a 3D model (mesh or other 3D CAD) has been created. In this case the control will only serve to position the model in space and will not cause distortion.

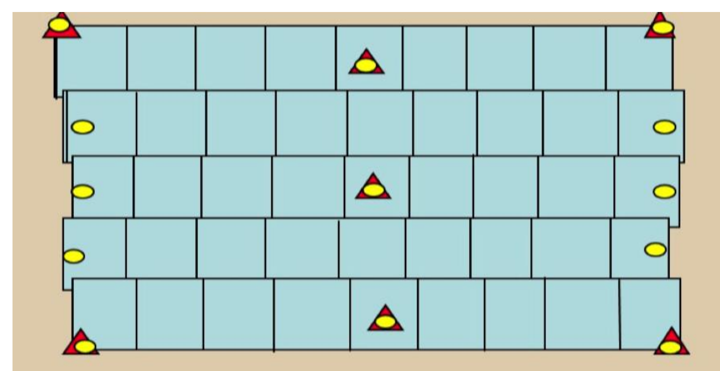
Control for CRP

In terrestrial photogrammetry there are basically four different methods of establishing control:

(1) Imposing the control on the camera by measuring its position and orientation with respect to a coordinate system or with respect to the photographed object
(2) Locating control points in the object space in a manner similar to locating control for aerial photography
(3) Combining camera control and object space control points
(4) Using a free-network adjustment with scale control only

In the second method of controlling terrestrial photos, points should be selected in the object space which provide sharp and distinct images in favorable locations in the photographs. Their positions in the object space should then be carefully measured. If no satisfactory natural points can be found in the object space, artificial targets may be required. Targets should be **designed** so that their images appear sharp and distinct in the photos. White crosses on black cards may prove satisfactory.

(a) (b)



3: Image processing and block triangulation

Most digital images captured in the field will require some digital processing, which include white balancing or any adjustments to the brightness, contrast, or other common image properties.

One important note is to never crop (or change the height/width in any way) an image intended for photogrammetry.

In order to extract three dimensional points from two dimensional images, it is necessary to perform **a triangulation** with at least two images (a stereo pair).

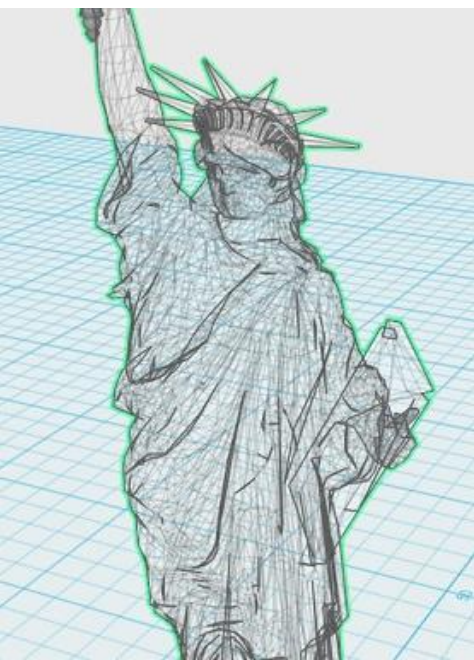
When more than two images are used in a triangulation, we refer to the group of images as a ‘block’.

In order to perform a triangulation of the entire block (known as a **bundle block adjustment**), the user must measure a sufficient number of tie, control, and/or check points throughout the block.

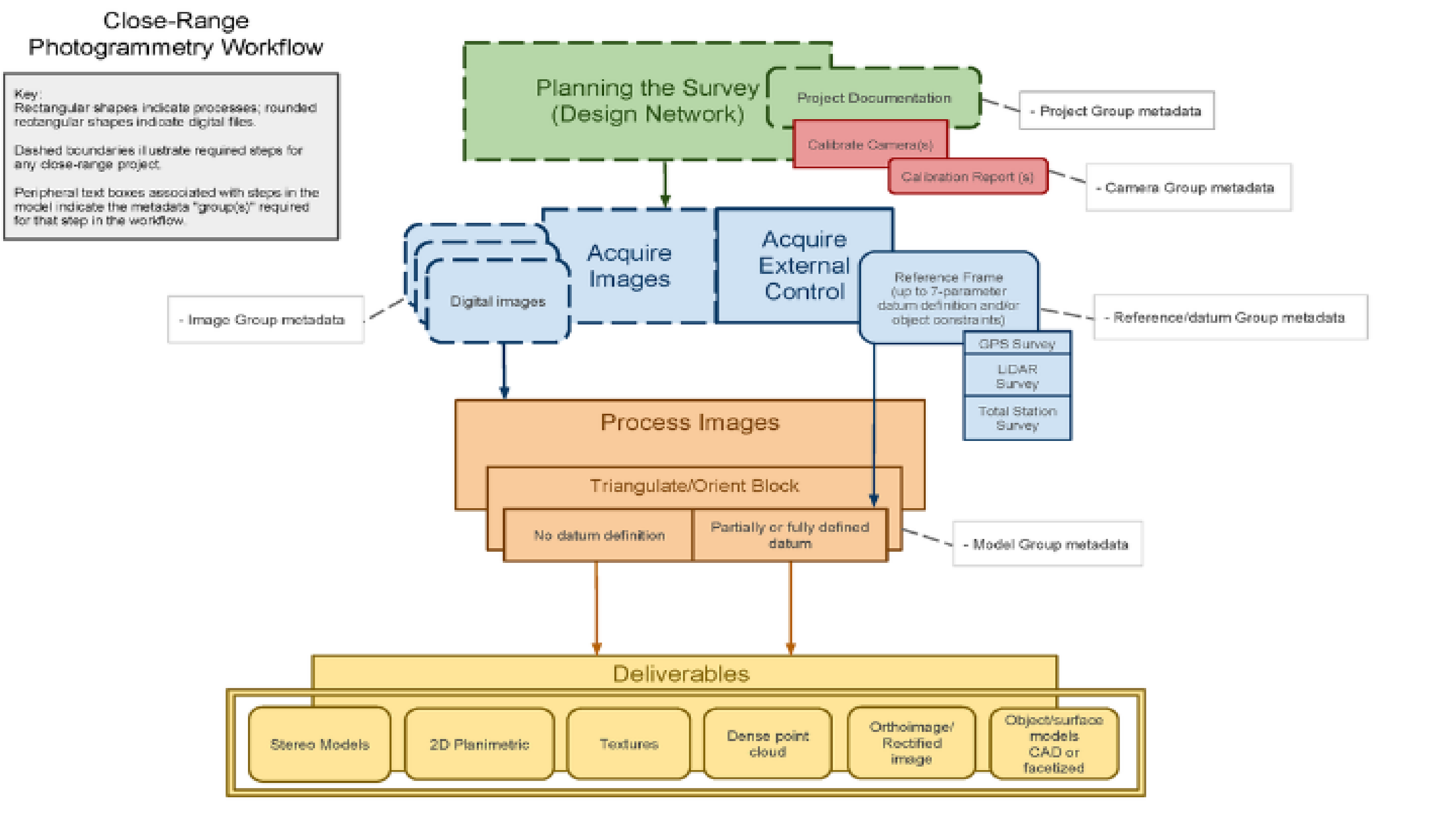
Constraints may also be placed on certain sets of points to enforce angular, linear, and/or planar properties. After a successful bundle adjustment, the user can extract and export 2D and/or 3D products.

4: Creating and exporting deliverables

Typical deliverables created as the end result of a CRP project could include 2D vector graphics (planimetric or elevation type CAD drawings), dense point clouds, 3D polylines, facetized models (mesh) of an object or surface, and raster graphics such as rectified or fully orthorectified images. Each deliverable created should include appropriate metadata for each of the above mentioned steps, as well as metadata for the additional processing performed to create the final file.




This workflow provides a graphic overview of the steps involved in a Close-Range Photogrammetry Project:



Basic Workflow of CRP Project

How to solve CRP problem?

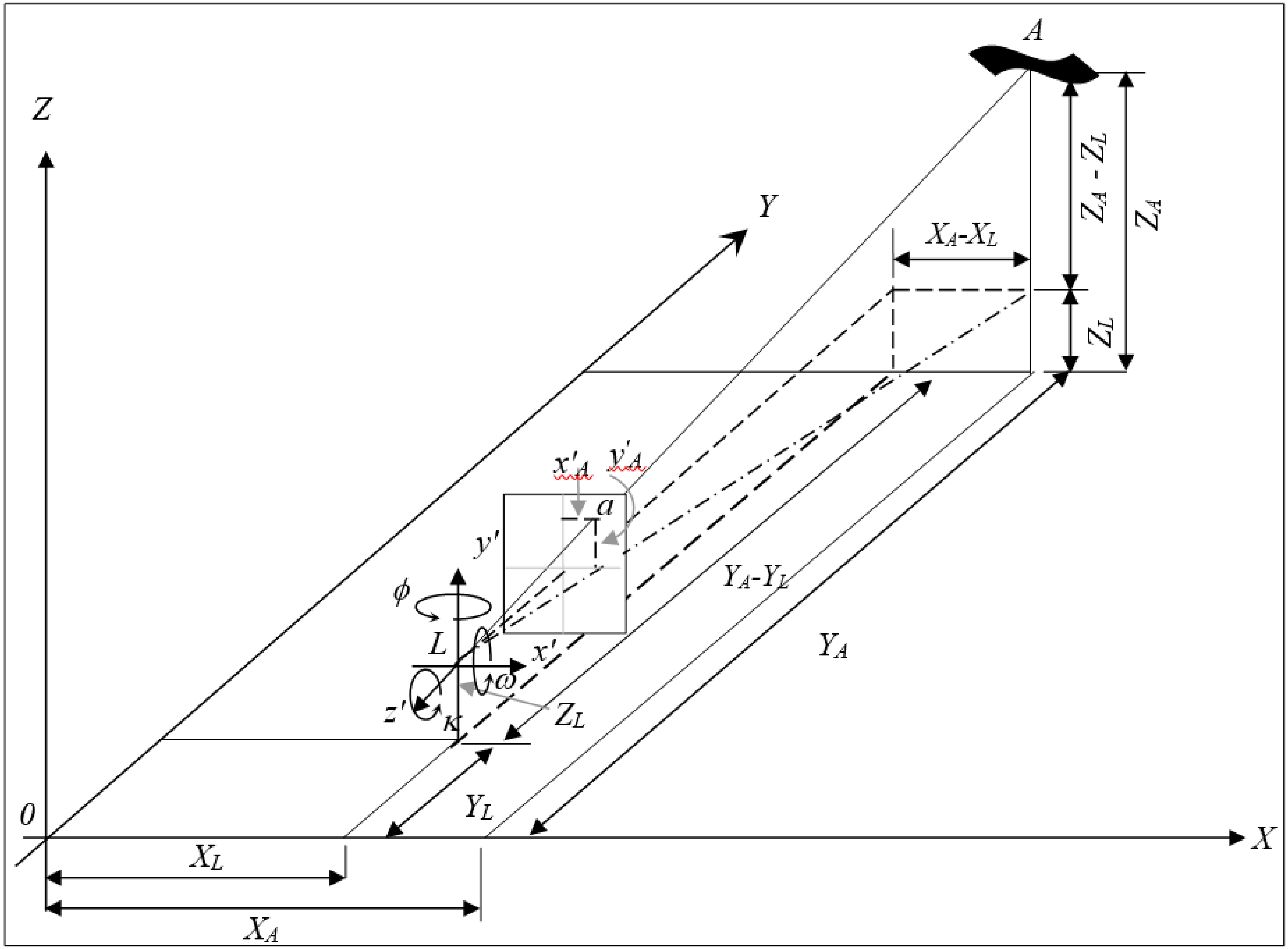
- There are two distinct solutions for any CRP problem:

- Colliniarity condition equations.
- Direct linear transformation (DLT) equations.

Collinearity condition in CRP

- In CRP, if rotation angles are considered in Anticlockwise then problem solution will be difference from the standard aerial case when collinearity condition is adopted!
- (x, y, z) parallel to (X, Y, Z) …. [AERIAL]
- (x, y, z) parallel to (X, Z, Y) …. [CRP]

Collinearity condition in CRP



Collinearity condition in CRP

$$x = -f * \left[\frac{m_{11}(X - X_L) + m_{12}(Z - Z_L) + m_{13}(Y_L - Y)}{m_{31}(X - X_L) + m_{32}(Z - Z_L) + m_{33}(Y_L - Y)} \right]$$

$$y = -f * \left[\frac{m_{21}(X - X_L) + m_{22}(Z - Z_L) + m_{23}(Y_L - Y)}{m_{31}(X - X_L) + m_{32}(Z - Z_L) + m_{33}(Y_L - Y)} \right]$$

Linearizing Collinearity Equations

- Elements of photogrammetry with applications in GIS, Paul R. Wolf, appendix D.

Acknowledgment Credits

- Barnes, Adam. 2011. Four Basic Steps of a Close-Range Photogrammetry Project. CAST Technical Publications Series. Number 7561.
- Elements of photogrammetry and applications in GIS, Paul R. Wolf, Bon A. Dewitt, Benjamin E. Wilkinson.
- Pix4D: Professional photogrammetry and drone mapping
- B. S. Alsadik, M. Gerke, and G. Vosselman, OPTIMAL CAMERA NETWORK DESIGN for 3D MODELING of CULTURAL HERITAGE, ISPRS Congress of Photogrammetry and Remote Sensing, 2012.
- University of Texas
- University of Florida
- University of Calgary