Photogrammetry

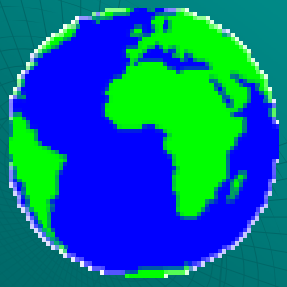
The Mechanics

The Photogrammetrists

- Kerry Williams

Zdenek Vymazal

Mike Gookin



Tina Arevalo

Kwik DRA - David Artman, Lead Photogrammetrist

How Photogrammetry Works

- Production of items
- Geometry of production
- Products

The Main Steps of Photogrammetry$_2$

1. Get mapping limits
2. Select scale
3. Plan flights & ground control
4. Place and survey premarks

The Main Steps of Photogrammetry (continued)$_2$

5. Aerial photography
6. Check aerial photos
7. Aerialtriangulation
8. Mapping

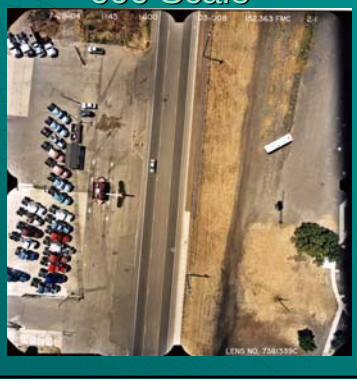
1. Get the Mapping Limits

2. Select the Necessary Scale

Large number,
Small scale
1:1000
1”= 1,000’

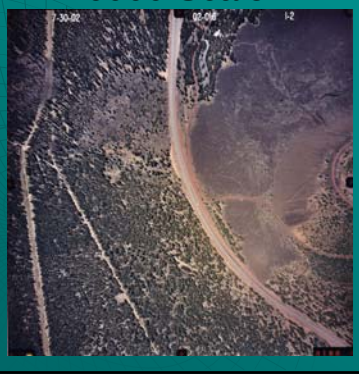
Small number,
Large scale
1:200
1”=200’

600 Scale



2000 Scale

6000 Scale



12000 Scale

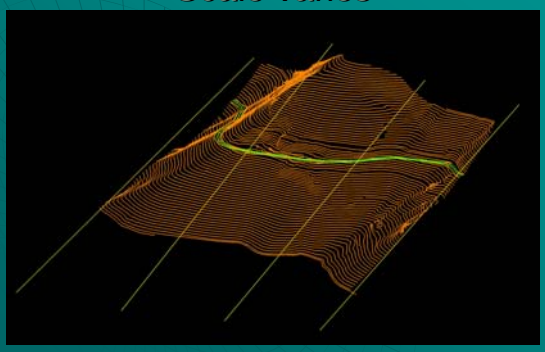
35000 Scale

Scale

$$S = \frac{f}{(H - h)}$$

f=focal length
S =scale
H=flying height
h=elevation of the point

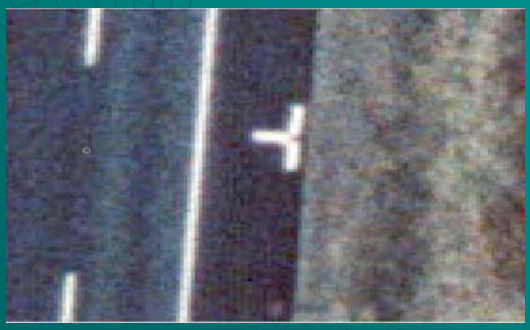
Scale varies



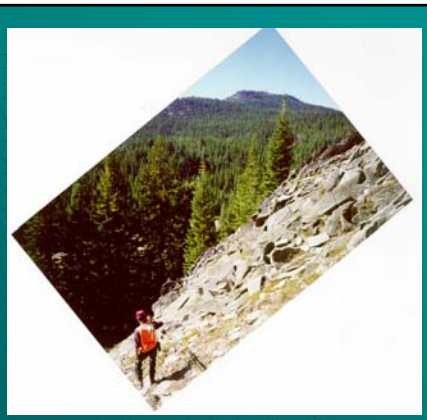
3. Plan Flights

3. Plan Ground Control

4. Place Premarks



4. Survey Premarks



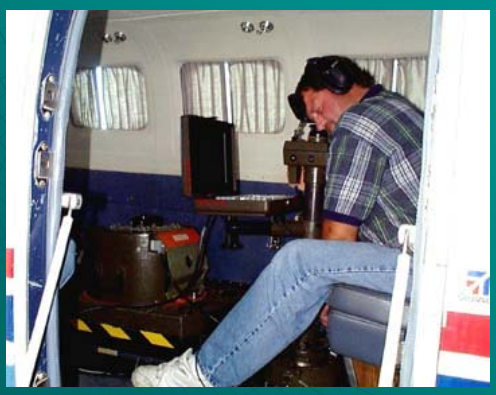
5. Aerial Photography

http://www.doh.dot.state.nc.us/preconstruct/highway/photo/camplane.htm#camera

Camera

Aerial Photographer

Flying Fingers



Factors Affecting Photography

Things we can't change

Nature

Sun Angle

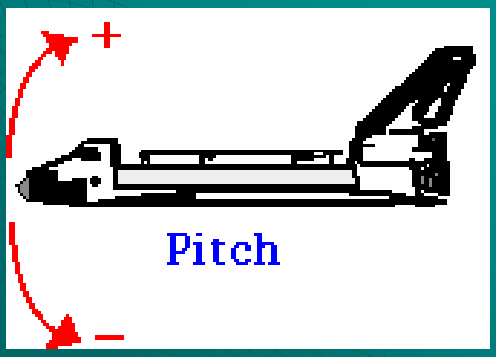
Shadows

Snow

Camera

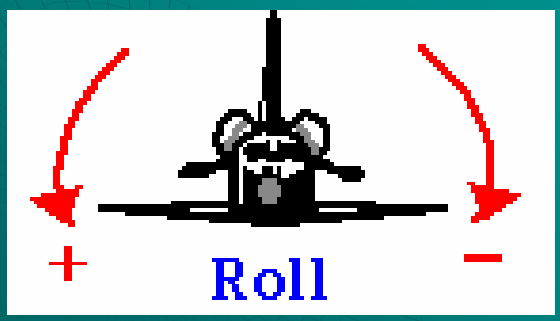
- Location
- Focal length
- Fiducials – reference marks

Tilt



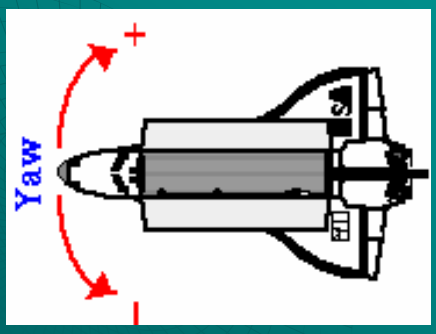
http://liftoff.msfc.nasa.gov/academy/rocket_sci/shuttle/attitude/pyr.html

Tilt

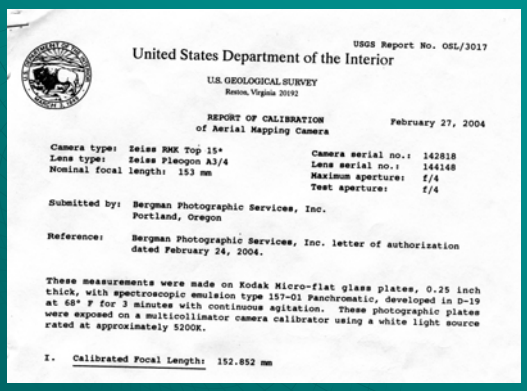


http://liftoff.msfc.nasa.gov/academy/rocket_sci/shuttle/attitude/pyr.html

Crab



http://liftoff.msfc.nasa.gov/academy/rocket_sci/shuttle/attitude/pyr.html



USGS Report No. OSL/3017

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

February 27, 2004

Camera type: Zeiss RMK Top 15*
Lens type: Zeiss Pleogon A3/4
Nominal focal length: 153 mm

Camera serial no.: 142818
Lens serial no.: 144148
Maximum aperture: f/4
Test aperture: f/4

Submitted by: Bergman Photographic Services, Inc.
Portland, Oregon

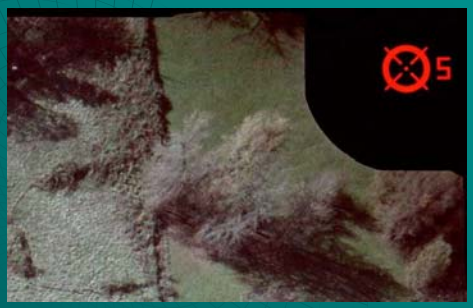
Reference: Bergman Photographic Services, Inc. letter of authorization dated February 24, 2004.

These measurements were made on Kodak Micro-flat glass plates, 0.25 inch thick, with spectroscopic emulsion type 157-01 Panchromatic, developed in D-19 at 68° F for 3 minutes with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using a white light source rated at approximately 5200K.

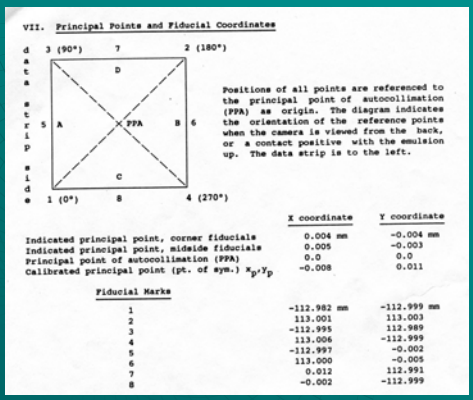
I. Calibrated Focal Length: 152.852 mm

Close Up of a Fiducial

Zoomed out shot of a Fiducial



All Eight Fiducials



VII. Principal Points and Fiducial Coordinates

Positions of all points are referenced to the principal point of autocollimation (PPA) as origin. The diagram indicates the orientation of the reference points when the camera is viewed from the back, or a contact positive with the emulsion up. The data strip is to the left.

	X coordinate	Y coordinate
Indicated principal point, corner fiducials	0.004 mm	-0.004 mm
Indicated principal point, mideide fiducials	0.005	-0.003
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	-0.008	0.011

Fiducial Marks		
1	-112.982 mm	-112.999 mm
2	113.001	113.003
3	-112.995	112.989
4	113.006	-112.999
5	-112.997	-0.002
6	113.000	-0.005
7	0.012	112.991
8	-0.002	-112.999

And now, back to our feature,

THE MAIN STEPS OF PHOTOGRAMMETRY

6. Check photography

Flight data

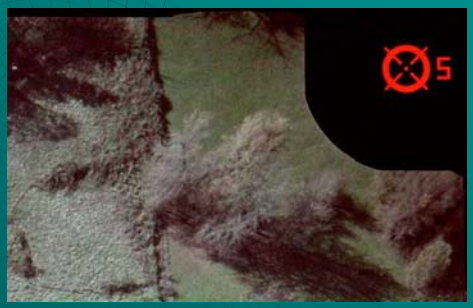
Weather

Sun angle

Endlap & Crab

Sidelap & Tilt

Fiducials



- Blur
- Exposure
- Scale

Relief Displacement

Biggest amount of error in aerial photography

- Points above the datum are displaced out (larger scale)
- Points below the datum are displaced in (smaller scale)

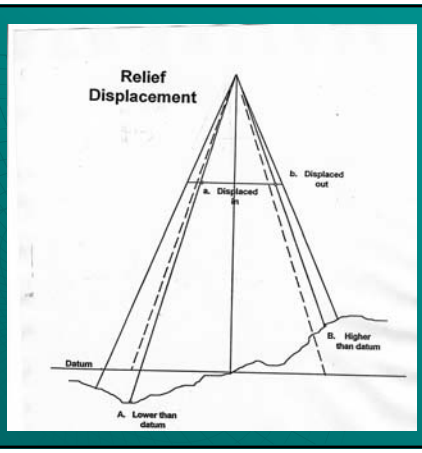
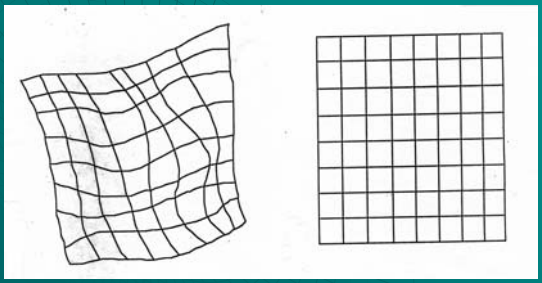
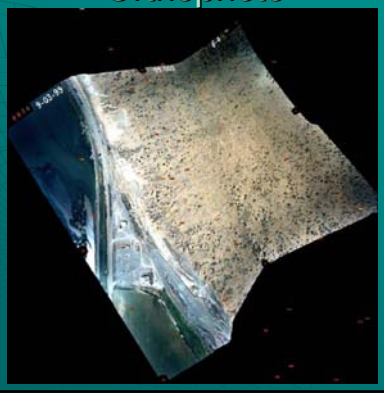


Image Map



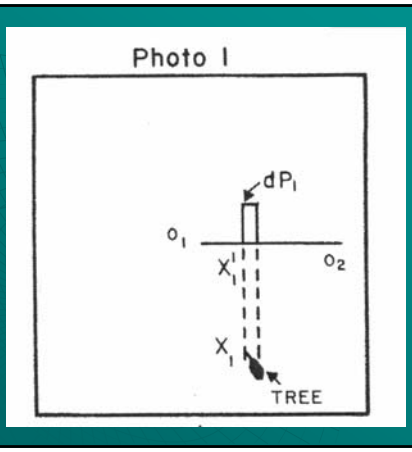
Aerial Photo

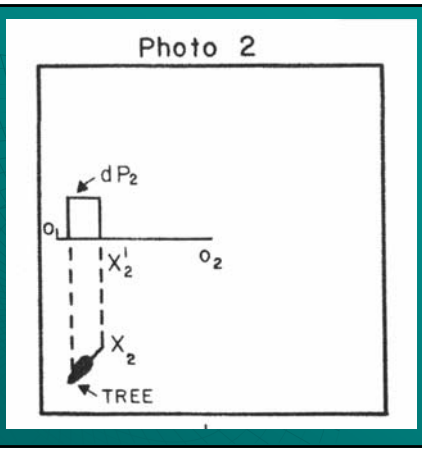
Orthophoto

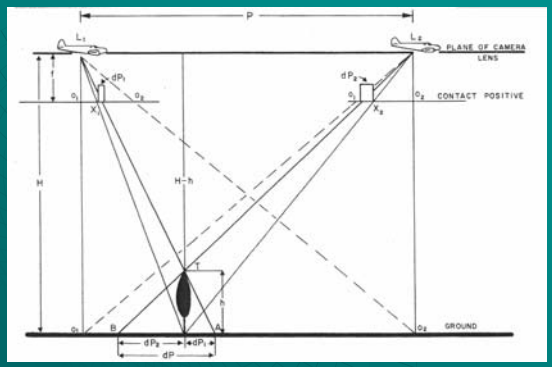


Three –Dimensional Vision

- Monocular view – flat (2D) perspective
- Binocular view – 3-D perspective



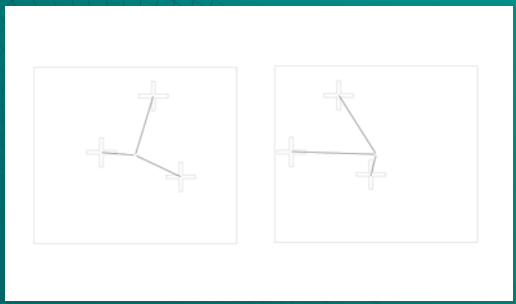




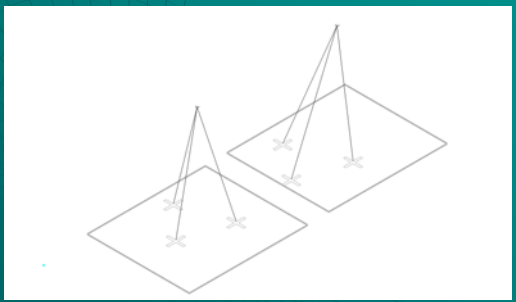
Aerial Triangulation

Triangulation in 3-D

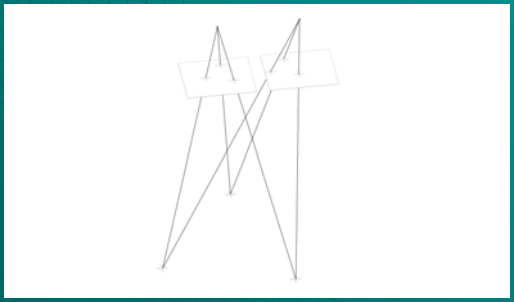
Angles & distances from camera to the ground are different for each photo



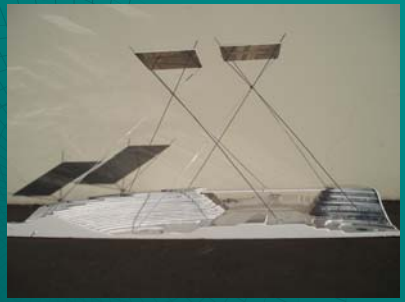
From camera to film

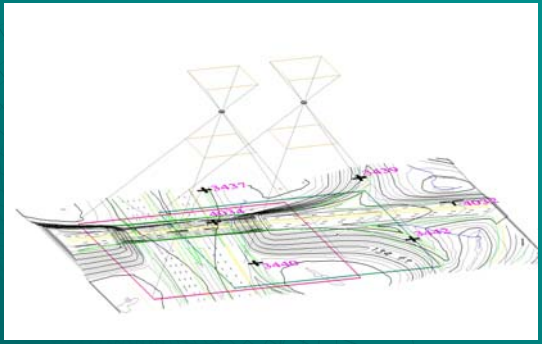


To the control on the ground



Model shows overlapping area





Known Values

- Control point coordinates
- Photo coordinate system
- Relation between stereo photos
- Focal length of camera

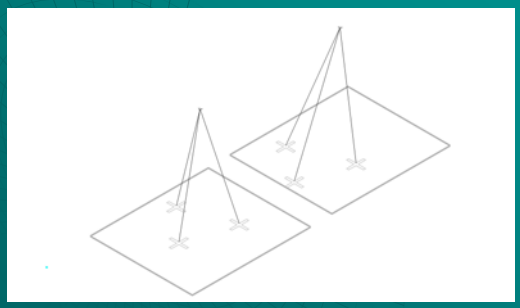
Unknowns to be Solved

- Camera position and orientation
- Positions on the ground

Interior Orientation

Done first (determines the relationship between the calibrated fiducial coordinates and the image pixel coordinates)

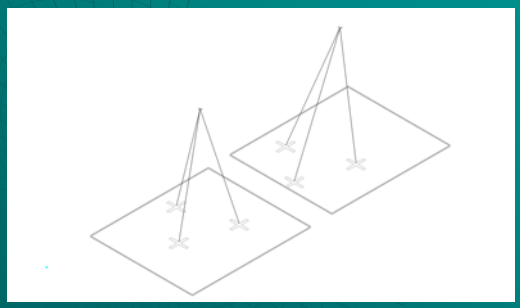
From camera to film



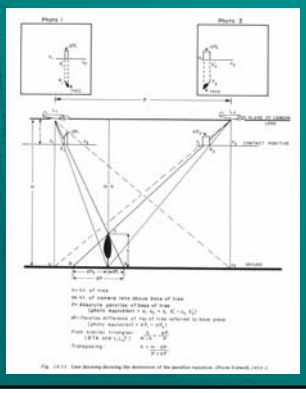
Relative Orientation

Determines the relationship between two images. The two images form a "model".

Same control points on sequential images

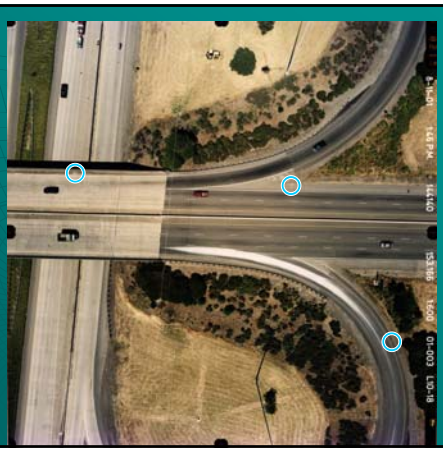


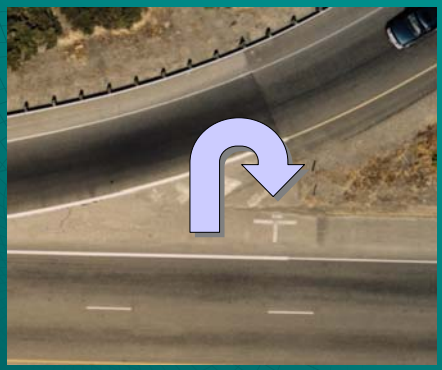
TWO IMAGES

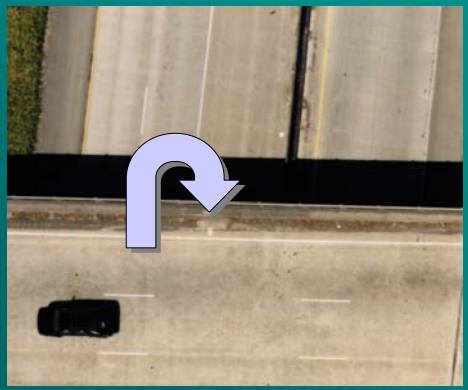


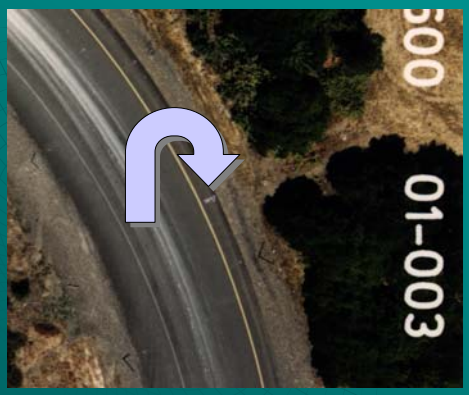
Absolute Orientation

Determines the relationship between image coordinates and the corresponding ground coordinates.









To the control on the ground

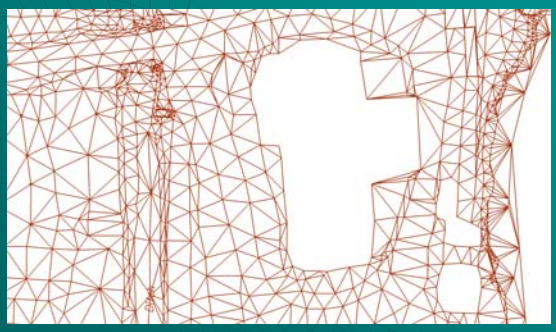
Products

Items are specific to client

- Digital or hard-copy media

MicroStation Drawings

InRoads DTMs



Aerial Images

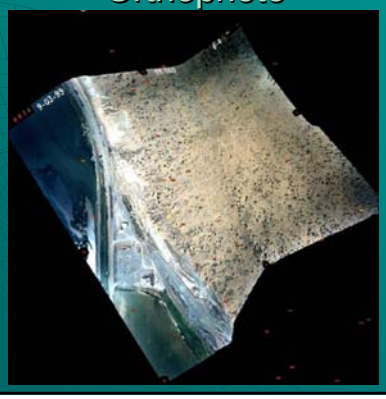
Aerial Photo

Rotation Matrix

R_{zxy} =

Cos(z)Cos(y) + Sin(z) Sin(x)Sin(y)	Sin(z)Cos(x)	Cos(z)-Sin(y) + Sin(z)Sin(x) Cos(y)
-Sin(z)Cos(y) + Cos(z)Sin(x) Sin(y)	Cos(z)Cos(x)	Sin(z)Sin(y) + Cos(z)Sin(x) Cos(y)
Cos(x)Sin(y)	-Sin(x)	Cos(x)Cos(y)

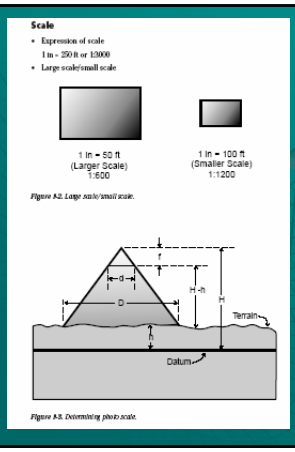
Orthophoto



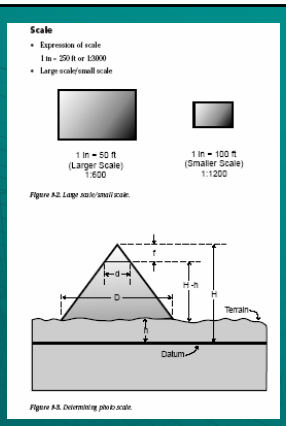
Orthophoto Mosaics

References

1. Anderson, James M. and Mikhail, Edward M., Surveying Theory and Practice, Seventh Edition, WCB/McGraw-Hill 1998, p.773.
2. Burns, Richard PLS, Caltrans Unit 9 Photogrammetry,
3. "Mapping and Orthophotos from Aerial Photography", OSU Forest Resources Dept., Corvallis, OR, 2000
4. Manual of Photogrammetry, 4th Edition, American Society of Photogrammetry, Falls Church, VA, 1980



Select the Scale of Mapping / Photography



Focal Length [2]

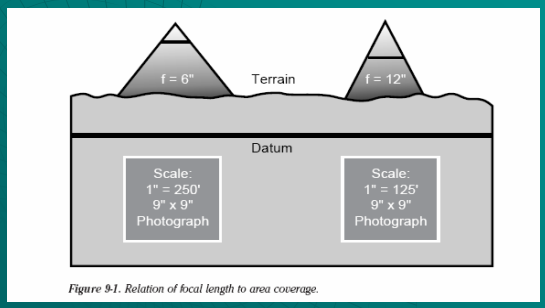


Figure 9-1. Relation of focal length to area coverage.

Aerial Triangulation (AT)

"Conjugate image rays projected from two or more overlapping photographs intersect at the common ground points to define the 3-d space coordinates of each point. The entire assembly of image rays is fit to known ground control points in an adjustment process. When the adjustment is complete, ground coordinates of unknown ground points are determined by the intersection of adjusted image rays.

- A "regular" vertical image of terrain has distortions due to tilt (pitch) displacement.
- A rectified photo has had the tilt displacements removed, so that it is like a map, except for the relief displacements.
- An orthophoto has had the tilt and relief displacements removed. "An orthophoto is equivalent to a planimetric map except that, instead of lines and symbols, image tonal variations convey the information."

Purpose of AT

- "to extend horizontal and vertical control from relatively few ground survey control points to each unknown ground point included in the solution. The supplemental control points are called pass points, and they are used to control subsequent photogrammetric mapping. Each stereomodel is scaled and leveled using the adjusted coordinate values of the pass points located in the stereomodel.

Orthophotos

Orthographic Projection: Projection of a single view of an object onto a drawing surface in which the lines of projection are perpendicular to the drawing surface

orth- Variant(s): *or* **ortho-**
Etymology: Middle English, from Middle French, straight, right, true, from Latin, from Greek, from *orthos;* akin to Sanskrit *urdhva* high, upright
1 : straight **:** upright **:** vertical <*ortho*grade>
2 : perpendicular <*ortho*rhombic>
3 : correct **:** corrective <*ortho*dontia>

rec·ti·fy
Etymology: Middle English *rectifien,* from Middle French *rectifier,* from Medieval Latin *rectificare,* from Latin *rectus* right –
1 : to set right **:** REMEDY
3 : to correct by removing errors **:** ADJUST <*rectify* the calendar>