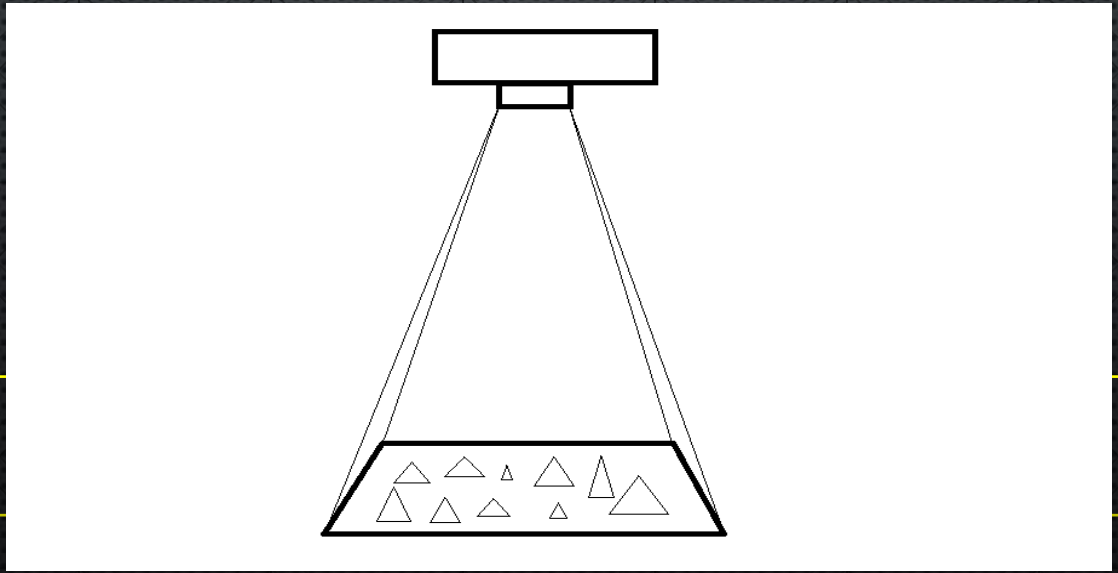
PRINCIPLES OF AERIAL PHOTOGRAPHY FOR FIRE MAPPING



OBJECTIVES

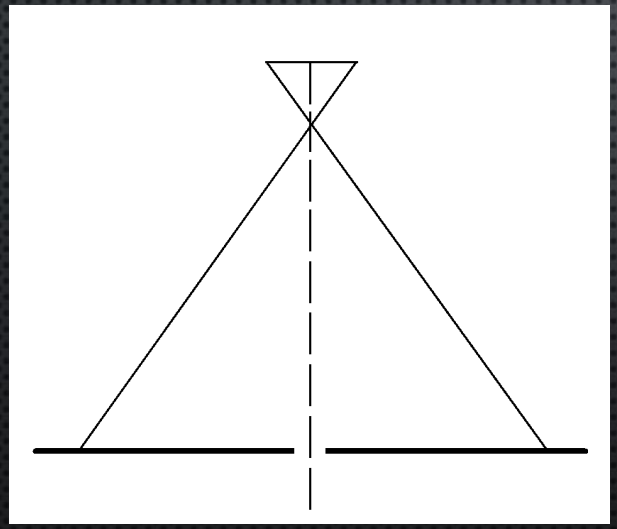
- Show the basic principles of collecting data for photogrammetry
- Show methods for collecting data on wildfire

Things to Consider for Product Quality

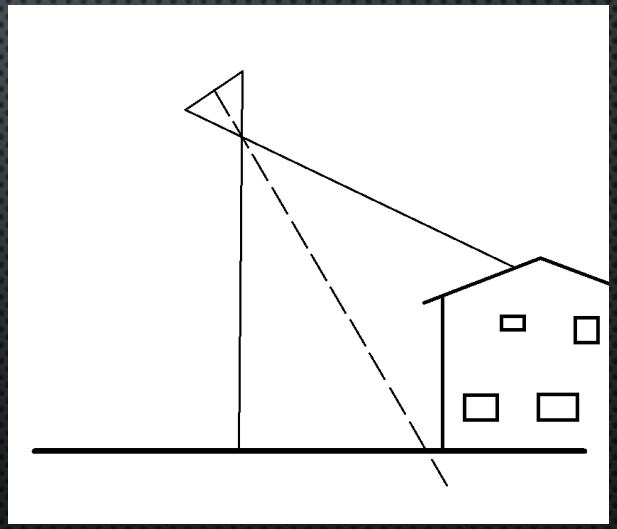
- Desired/Needed Resolution
- What is the desired product (3D model, Orthophoto, DEM, FMV)
- How precise does the product need to be
- Is the End Result feasible
- Are shadows a concern or needed
- Time required to acquire
- Is there a better way
- Weather/Wind

TWO BASIC CAMERA POSITIONS

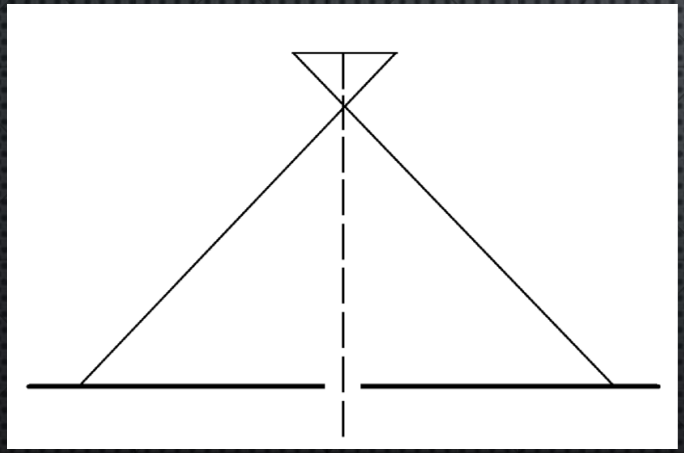
Vertical(Nadir)



Low oblique

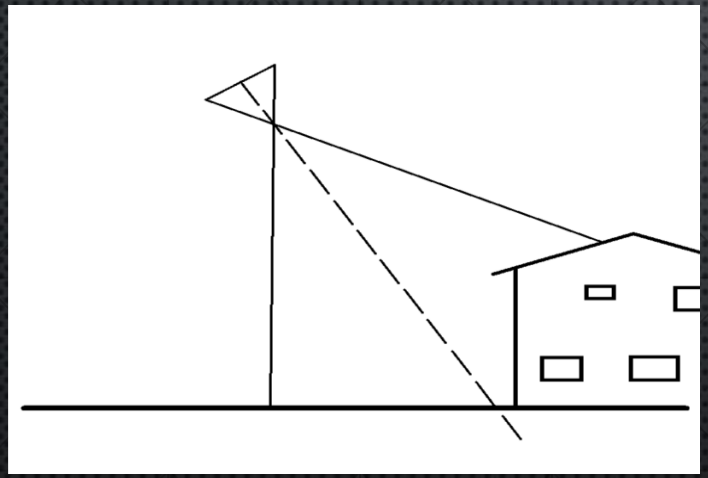


VERTICAL



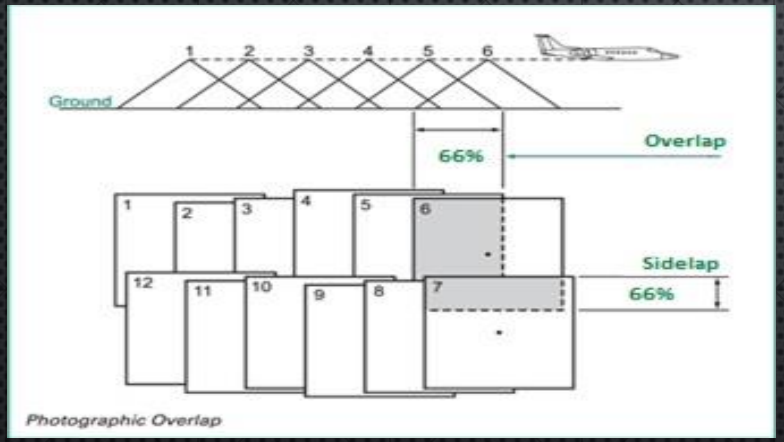
- Most common position used for aerial mapping

LOW OBLIQUE



- Used to capture vertical faces in 3D modeling
- Multiple angles can be used
- Take care to not get the horizon in photos
- No more than 10 degrees offset from other data sets

OVERLAP/SIDELAP



Photogrammetry News

- For Photogrammetry software to align photos and have best results we use 66% sidelap and 66% overlap
- This needs to be based on the highest point in the area covered

GEOMETRY

Base to Height Ratio

Base is the distance in sidelap from one photo to the next.
Height is the altitude being flown
Ideal Base to Height is <1:3

If flying at 100’ with 66% sidelap flight lines are 44’ apart.

100/44=2.27 The Base to Height is 1:2.27

This means that the height accuracy of your model will be 2.27 times worse than the planimetric(horizontal plane) accuracy. It will manifest in the error values in Photoscan.

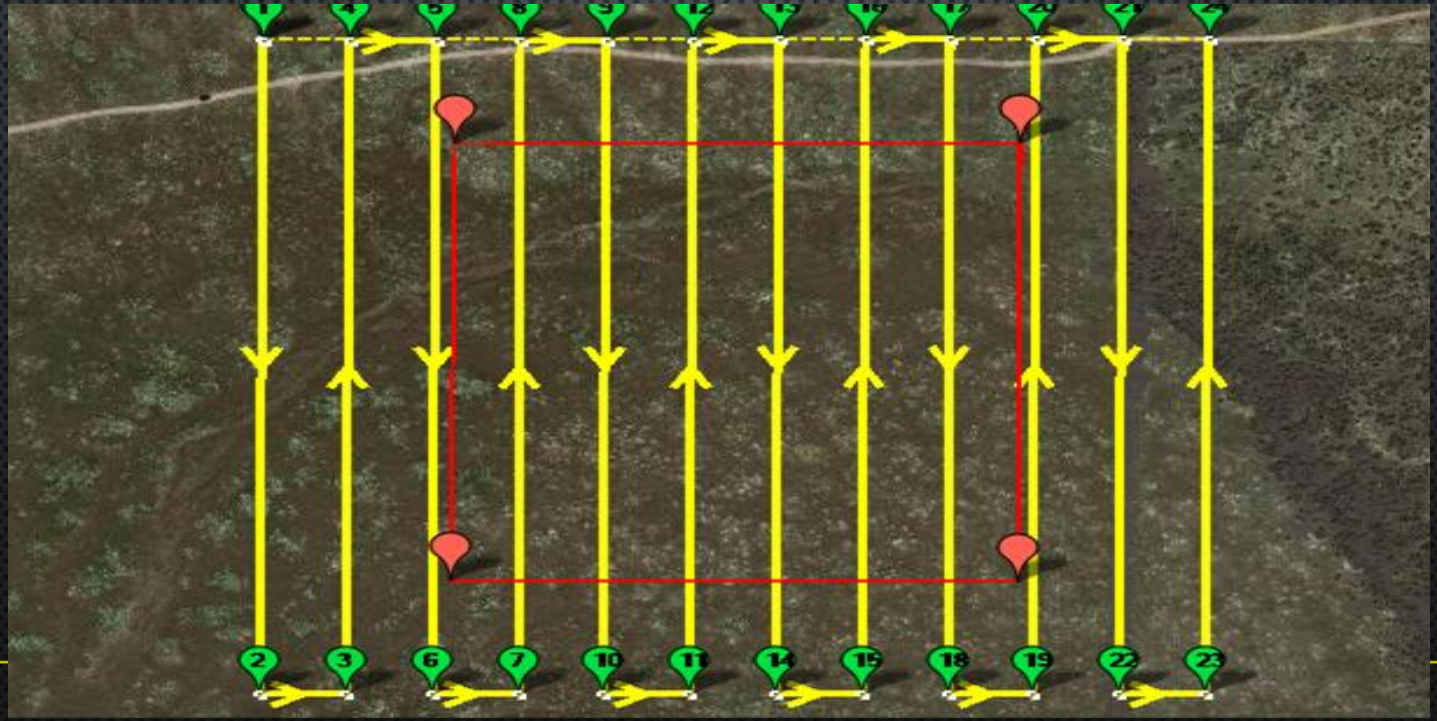
GEOMETRY

Base to Height Ratio

With the current aircraft setups the camera top faces forward on the aircraft. The base distance is the same as the distance between flight lines. Height is altitude. Using the apps and programs as we teach and are setup this should not be a problem unless there is a wide variation in terrain (altitude changing with rolling terrain).

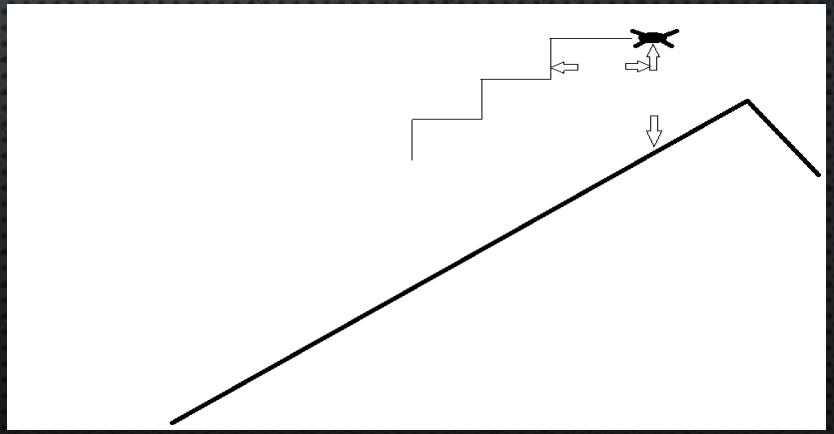
FLIGHT AREA VS. MAP AREA

A minimum of 3 flight lines are needed outside of the area of interest in order to have the geometry work in processing.



OVERLAP VS TERRAIN

- Altitude change can not be more than 50% of altitude of last transect or last picture
- This technique needs to be carefully planned out to not interfere with alignment and avoid CFIT



CAMERA CALIBRATION

- Needed for Software to determine distortions in camera lens
- For high quality data processing there needs to be photos with the camera turned +90 and -90 degrees from the primary direction.
- Simple orthophoto needs a few photos
- 3D models or volumetric require a high ratio of crossing flight lines

CAMERA TRIGGER TYPES

Intervalometer

- Camera triggering is done with timer in the camera
- + Consistent trigger timing
- - Can't stop the triggering remotely
- - Required to calculate trigger distance/speed

Autopilot Trigger

- Camera triggering is done by the autopilot
- + Only take photos of the required area
- - Periodic misfire of the trigger
- Use ODS to ensure proper operation

FLIGHT ALTITUDE

- Fly only as low as needed to meet objective
- Higher means fewer photos and lower resolution
- With the cameras we use figure 1cm per 100’ for resolution.
- MicaSense cameras do about 2cm resolution per 100’

FLIGHT SPEED

- If flown too fast photos maybe blurry
- Consider time needed for camera to write to the SD card
- Depending on aircraft may not be adjustable

SPEED VS ALTITUDE

- The higher you are the faster you can fly
- Too fast and photos become blurry
- Use the Object Distance Spreadsheet to calculate

OBJECT DISTANCE SPREADSHEET

Input values in YELLOW boxes. Adjust speed, altitude, shutter speed to reach desired settings. Capture interval needs to be > than 1 second minimum.

Camera Model:	FLIR Duo EO	<----Select Sensor with Drop-Down

Camera/Lens Parameters		Units:	Formula Notes:
Width in Pixels	4000	pixels	
Height in Pixels	3000	pixels	
Image Sensor Width	7.6	mm	
Image Sensor Height	5.7	mm	
Pixel Size	0.001900	mm/pix	Image Sensor Width / Width in Pixels
Lens Focal Length	8	mm	

Imagery Collection Parameters			
Flying Speed	**35**	**mph**	
Flying Speed	15.65	m/sec	
Flying Speed	30.41	knots	
Flight Height (AGL)	**2530**	**feet**	
Flight Height (AGL)	771.14	meters	
Imagery GSD	0.1831	m/pix	Pixel Size * Flight Height / Lens Focal Length
Imagery GSD	18.315	cm/pix	
Capture Interval	11.94	sec	Distance Between Images / Flying speed
Minimum Required Shutter Speed 1/	300	sec	1/3 Pixel of Movement During Exposure

Image Footprint Size			
Footprint Width	732.59	meters	Width in Pixels * GSD (m)
Footprint Height	549.44	meters	Height in Pixels * GSD (m)
Footprint Width	2403.50	feet	
Footprint Height	1802.63	feet	

Overlap and Sidelap			
Overlap	**66**	**%**	Recommended Value of 66% (RedEdge-M 75%)
Distance Between Images	186.81	meters	Footprint Height * (100-Overlap)/100
Distance Between Images	612.89	feet	
Sidelap	**66**	**%**	Recommended Value of 66% (RedEdge-M 75%)
Flight Line Spacing	249.08	meters	Footprint Width * (100-Overlap)/100
Fligth Line Spacing	817.19	feet	

Created by the BLM NOC Geospatial Section

Contact Mark Gapinski with questions (mgapinski@blm.gov)

= Values change with selected sensor

= Parameters to enter

= Values of note

Area of Intrest (AOI)		Units:	Formula Notes:
AOI Width	**5000**	**feet**	
AOI Width	1524.00	meters	
AOI Height	**5000**	**feet**	
AOI Height	1524.00	meters	
AOI Area	573.9	US acres	
Number of Flight Lines in AOI	7		AOI Width / Flight Line Spacing
Number of Images per Flight Line	9		AOI Height / Distance Between Images
Estimated Number of Images	63		Flight Lines in AOI * Images per Flight Line
Estimated Survey Time	0:12:32	hh:mm:ss	Number of Images * Capture Interval

Ideal Camera Settings for Stereo Image Collection	
Camera Mode	Shutter & Aperture Priority
Focus Distance	Infinity
Shutter Speed	1/2500 or Faster
F-Stop (Aperture)	F 5.0 - F 8.0
ISO	100 - 1000

Direction of Camera in Flight

SOLAR NOON

- Solar noon is when the sun crosses the meridian and is at its highest elevation in the sky, at 12 o'clock apparent solar time. The local or clock time of solar noon depends on the longitude and date.

Definition from Wikipedia

- NOAA Solar Calculator

CAMERA SETTINGS

There are several settings that need to be set for quality imagery to be collected. Each setting can have an effect on others if changed.

SETTINGS

- Mode (Manual, Shutter Priority or Aperture Priority)
- Shutter Speed
- ISO
- F-Stop
- Focus

MODE

- Shutter Priority – User set Shutter Speed and camera sets the F-Stop
- Aperture Priority – User sets F-Stop and camera sets the Shutter Speed
- Manual – User defines settings for both

SHUTTER SPEED

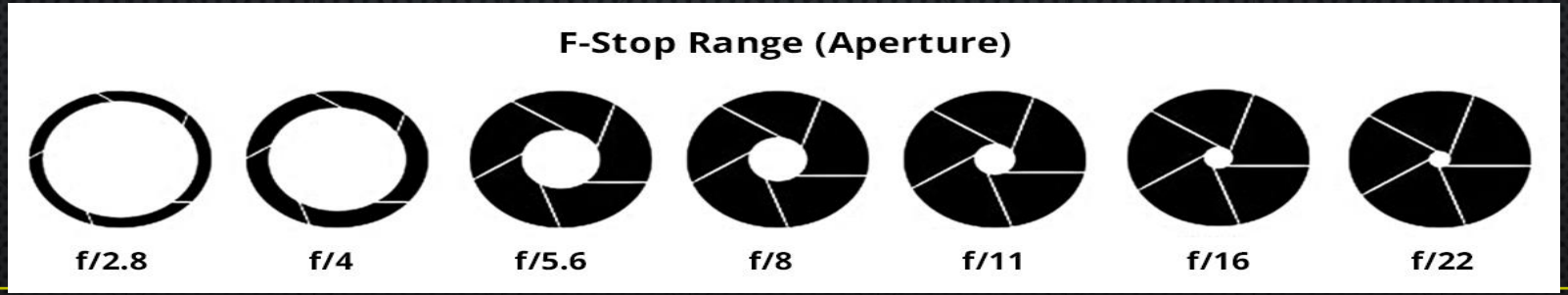
- Time the shutter is open at a given setting
- One of the controls to how much light is allowed in
- Expressed in fraction of 1 second
- 1/500th of a second will let in half as much light as 1/250th
- Too low speed will make photos blurry due to aircraft movement
- Typical for our use is 1/2000 to 1/3200

ISO

- ISO is a measurement of the sensitivity of the camera sensor
- Lower number is better, higher numbers the photos become grainy
- Typical settings for AP work is 100-400
- On a partly cloudy day consider floating the ISO

F-STOP

- Also called Aperture, is how far the shutter opens when a photo is taken.
- The smaller the F-Stop number the wider the shutter opens.



FOCUS

- Set to Infinity if possible for most projects
- For volumetric projects do not use auto focus as it will skew the model

INTER RELATIONSHIP

- It's all about how much light reaches the camera sensor
- A shutter speed of 1/50s with an *f*/4.0 aperture gives the same exposure value as a 1/100s shutter speed with an *f*/2.8 aperture, and also the same exposure value as a 1/200s shutter speed with an *f*/2.0 aperture, or 1/25th second at f/5.6.

Wikipedia

EXPOSURE VALUE

- The F-Stop, Shutter Speed and scene luminance all determine the amount of light that reaches the camera sensor.
- EV Accounts for the Shutter Speed and F-Stop
- EV combined with ISO determines Under, Over or Properly Exposed photos

FOR AERIAL PHOTOGRAPHY WORK

- Typically will want a higher Shutter Speed to eliminate blur from aircraft movement 1/2000 to 1/3200 (Slower cloudy days, faster sunny days)
- An F-Stop of 8.0 to 5.6 (5.6 lower light, 8.0 brighter light)
- ISO 100-400 (lower bright light, higher low light)

TOM NOBLE ADVICE

- NO autofocus
- NO rolling shutter
- NO or very little image compression
- NO change in aperture
- NO motion blur

SHUTTER TYPE

Rolling Shutter

- Scans the scene and records to card one line at a time
- Scanning induces blur to the photos from moving aircraft

Global shutter

- Entire frame is captured at the same instant and recorded to the card

SHUTTER TYPE

Rolling Shutter

PetaPixel

SHUTTER TYPE

Global Shutter

DP Review

PHOTO FILE FORMATS

- JPEG
  - Most common used, compressed
- RAW
  - Used in event that adjustment is required, no compression(lossless)
- TIFF
  - Used with FLIR and RedEdge cameras, no compression(lossless)

CHANGING CAMERA SETTINGS

Ricoh GR2

- GR Remote App to change settings
- Triggering through AP or timer
- Sync tablet clock with GR
- TURN OFF WIRELESS BEFORE FLIGHT

CHANGING CAMERA SETTINGS

DJI XT2

- Flight App to change settings
- For photogrammetry camera needs to be set to timer
- Build flight plan for which sensor is desired(Thermal has narrower FOV)

CHANGING CAMERA SETTINGS

FLIR Vue Pro R

- FLIR UAS App to change settings
- Build flight plan for which sensor is desired
- Camera is connected via Bluetooth
- Care must be taken while making adjustments to not change calibration
- If calibration is off camera must go to factory for calibration

CHANGING CAMERA SETTINGS

MicaSense RedEdge

- Settings are done via website address and wireless on tablet
- Camera time is taken from the connected GPS module
- Triggering through AP or timer
- Tablet must be very close to camera to connect, a few inches
- Wireless is very low power and can not be turned off

SUMMARY

Questions?