Best Practices for Managing Aerial and UAS Frame Imagery

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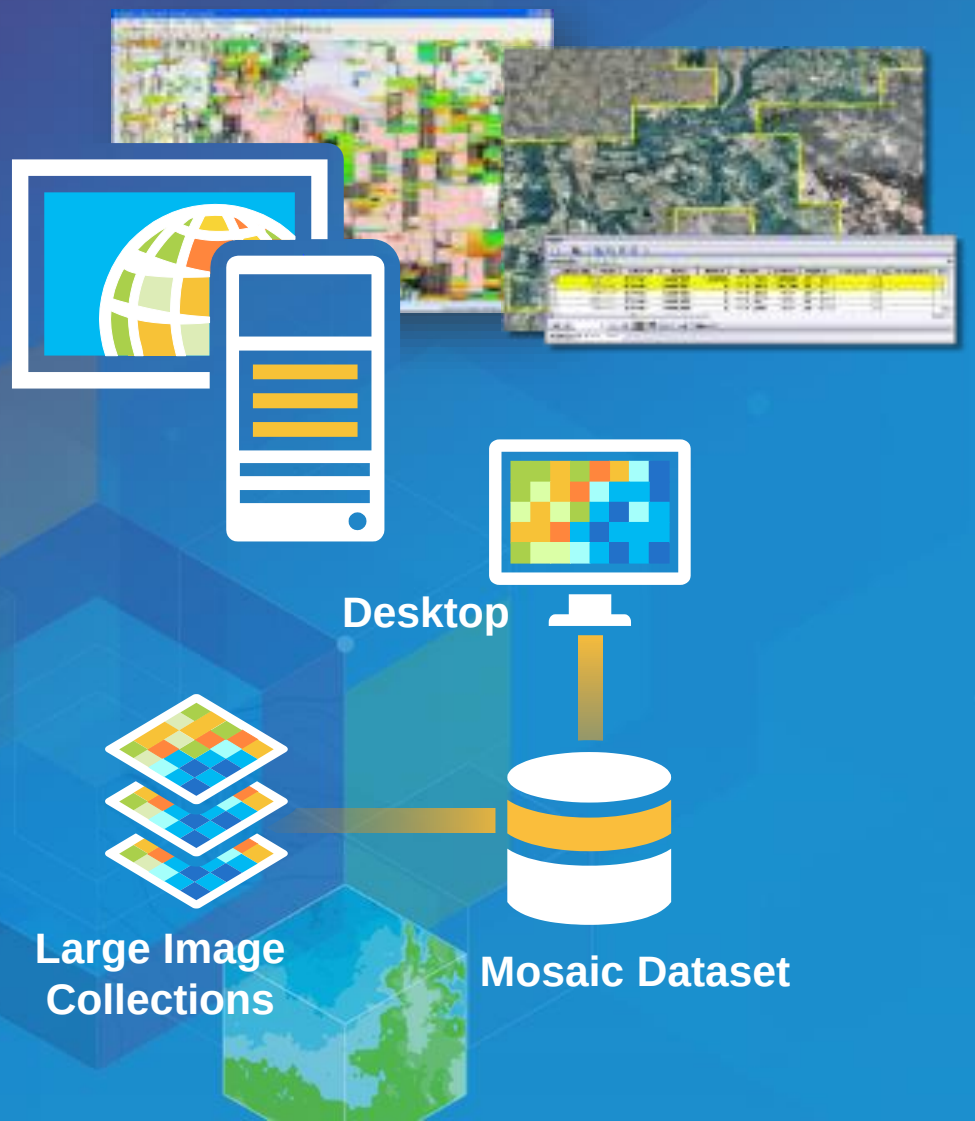
Objectives

- Manage and share collections of imagery from aerial frame cameras
  - Professional digital cameras
    - Metric lens, precise positioning with GPS & IMU
  - Uncalibrated frame cameras on unmanned aerial systems (UAS) or drones
  - Intent is to manage & process single, unprocessed images from the sensor; Preprocessed Orthophotos from a data provider are a different use case…

Image Management Workflow Using Mosaic Datasets

Highly Scalable, From Small to Massive Volumes of Imagery



Create Catalog of Imagery

- Reference Sources
- Ingest & Define Metadata
- Define Processing to be Applied

Apply:

- On-the-fly Processing
- Dynamic Mosaicking

Access as Image or Catalog

Support for Aerial and UAV/UAS Imagery data

- Use Mosaic Dataset to manage both film and digital frame camera data
- A generic solution to support thousands of different cameras
- Required information:
  - Interior orientation (camera parameters)
  - Exterior orientation (unique frame parameters)

Basic workflow in ArcGIS

- Create Mosaic Dataset
- Use the appropriate Raster Type to ingest data from different sensors
  - Applanix
  - Match-AT
  - Frame Camera *(added at 10.3.1)*
- Populate integrated metadata into Mosaic Dataset
  - Sensor location (x,y,z) and orientation (o,p,k)
  - Other metadata may be added to facilitate management & analysis
- Share as image service (optional)

Two approaches

- Images with complete orientation parameters
  - LeadAir
  - UltraCam
  - etc.

→ Generate Frames and/or Cameras table from calibration report, etc.

- Orientation parameters generated by software
  - Drone2Map for ArcGIS
  - Pix4d Mapper™
  - Harris/Icaros OneButton™
  - etc.

→ Generate Frames and/or Cameras table from exported project report.

Prepare inputs for *Frame Camera* Raster Type

- **Consolidate exterior/Interior orientation parameters**
  - **GPS file**
  - **Camera file**
  - **Frame parameters file (*.txt, *.csv, or *.xml)**

- **Create Frames and/or Cameras table**
  - **Format the orientation parameters to *Frame Camera* Raster Type schema**
  - **Supports radial distortion correction**
  - **Works for any camera**
  - **Input format can be csv/txt/feature class/GDB table**

See in ArcGIS Help System:
http://esriurl.com/FrameSchema
http://esriurl.com/CameraSchema

Demo

Mosaic dataset workflow

Frame Camera Raster Type – Exterior orientation

Frame table

- Required: PerspectiveX/Y/Z and image path (relative or absolute)
- Omega/Phi/Kappa
- Add raster info fields to speed up ingest process
  - NCols, NRows, NBands, PixelType, SRS

NCols	NRows	NBands	PixelType	SRS
10328	7760	3	8_BIT_UNSIGNED	32617
10328	7760	3	8_BIT_UNSIGNED	32617
10328	7760	3	8_BIT_UNSIGNED	32617

PerspectiveX	PerspectiveY	PerspectiveZ	Omega	Phi	Kappa
461681.6722	3158470.35	809.574638	-0.064682	-0.139704	-179.71770
461683.087	3158371.445	811.472574	-0.028823	-0.063748	-179.64660
461682.6709	3158272.916	811.971936	-0.105496	0.456202	-179.51621
461682.0233	3158173.322	812.724519	-0.080568	0.000266	-179.54476
461681.5294	3158074.227	813.701214	-0.0777	0.206639	-179.64853
461681.6746	3157975.307	814.514642	-0.052909	0.052173	-179.56249
461682.6923	3157876.594	815.005899	-0.020786	-0.014977	-179.84698
461684.4121	3157777.858	814.663818	-0.035867	-0.058924	-179.74516
461685.7635	3157679.019	813.618601	-0.037719	0.139921	-179.61517
461685.702	3157580.669	811.834429	-0.056909	0.199438	-179.73050

Frame Camera Raster Type – Interior orientation

Camera table

- Focal length (microns)
- Principal point (microns)
- Image to camera affine transformation
- AverageZ or DSM
- Radial/Konrady correction

$$x' = x \cdot (K_0 + K_1 \cdot r^2 + K_2 \cdot r^4 + K_3 \cdot r^6 + K_4 \cdot r^8)$$
$$y' = y \cdot (K_0 + K_1 \cdot r^2 + K_2 \cdot r^4 + K_3 \cdot r^6 + K_4 \cdot r^8)$$

Konrady	DistortionType
0;0.000006203849275567615;0.000000001507653161474 0	Konrady
0;-0.000005255050861466862;0.000000001246376547415	Konrady
0;-4.704485025411438e-006;6.743669916587011e-010;2.3	Konrady
0;-4.230792121983367e-006;5.478852084089317e-010;2.2	Konrady
0;-4.816412245242294e-006;1.006678147477097e-009;-1.1	Konrady

FocalLength	PrincipalX	PrincipalY
79887.2	-13.3	-54.6
108158.9	59.9	-147.8
108456.5	-10.3	-3.9
108442.3	-12.2	9.2
108262.6	45.6	-217.4

C = ((cols/2)-0.5) * PS)
R = ((rows/2)-0.5) * PS)

A0= -C
A1=PS
A2=0
B0=R
B1=0
B2=-PS

A0	A1	A2	B0	B1	B2
-26852.8	5.2	0	20176	0	-5.2
-26852.8	5.2	0	20176	0	-5.2
-26852.8	5.2	0	20176	0	-5.2
-26852.8	5.2	0	20176	0	-5.2
-26852.8	5.2	0	20176	0	-5.2

where PS is camera's film pixel size in microns.

Convert Drone2Map project to Mosaic Dataset

- Drone2Map project contains calibrated interior/exterior orientation parameters
- Custom python tool to convert Drone2Map project to mosaic dataset
- Provide mosaic view of the drone image collection without generating single ortho mosaic image

AerialPhoto&UAV › Cadastre › Cadastre_drone2map › process › Cadastre_drone2map › 1_initial › params

Name	Date modified
Cadastre_drone2map_calibrated_camera_parameters.txt	6/24/2016 5:08 PM
Cadastre_drone2map_calibrated_external_camera_parameters.txt	6/24/2016 5:08 PM
Cadastre_drone2map_calibrated_external_camera_parameters_wgs84.txt	6/24/2016 5:08 PM
Cadastre_drone2map_calibrated_external_camera_position_error.txt	6/24/2016 5:08 PM
Cadastre_drone2map_calibrated_images_position.txt	6/24/2016 5:08 PM
Cadastre_drone2map_calibrated_internal_camera_parameters.cam	6/24/2016 5:08 PM
Cadastre_drone2map_camera.ssk	6/24/2016 5:08 PM
Cadastre_drone2map_offset.xyz	6/24/2016 5:08 PM
Cadastre_drone2map_photo.ssk	6/24/2016 5:09 PM
Cadastre_drone2map_pix4d_calibrated_internal_camera_parameters.cam	6/24/2016 5:08 PM
Cadastre_drone2map_pmatrix.txt	6/24/2016 5:08 PM
Cadastre_drone2map_tp_bingo.txt	6/24/2016 5:09 PM
Cadastre_drone2map_tp_orima.txt	6/24/2016 5:09 PM
Cadastre_drone2map_tp_pix4d.txt	6/24/2016 5:09 PM
Cadastre_drone2map_wkt.prj	6/24/2016 5:08 PM

Oblique Image support

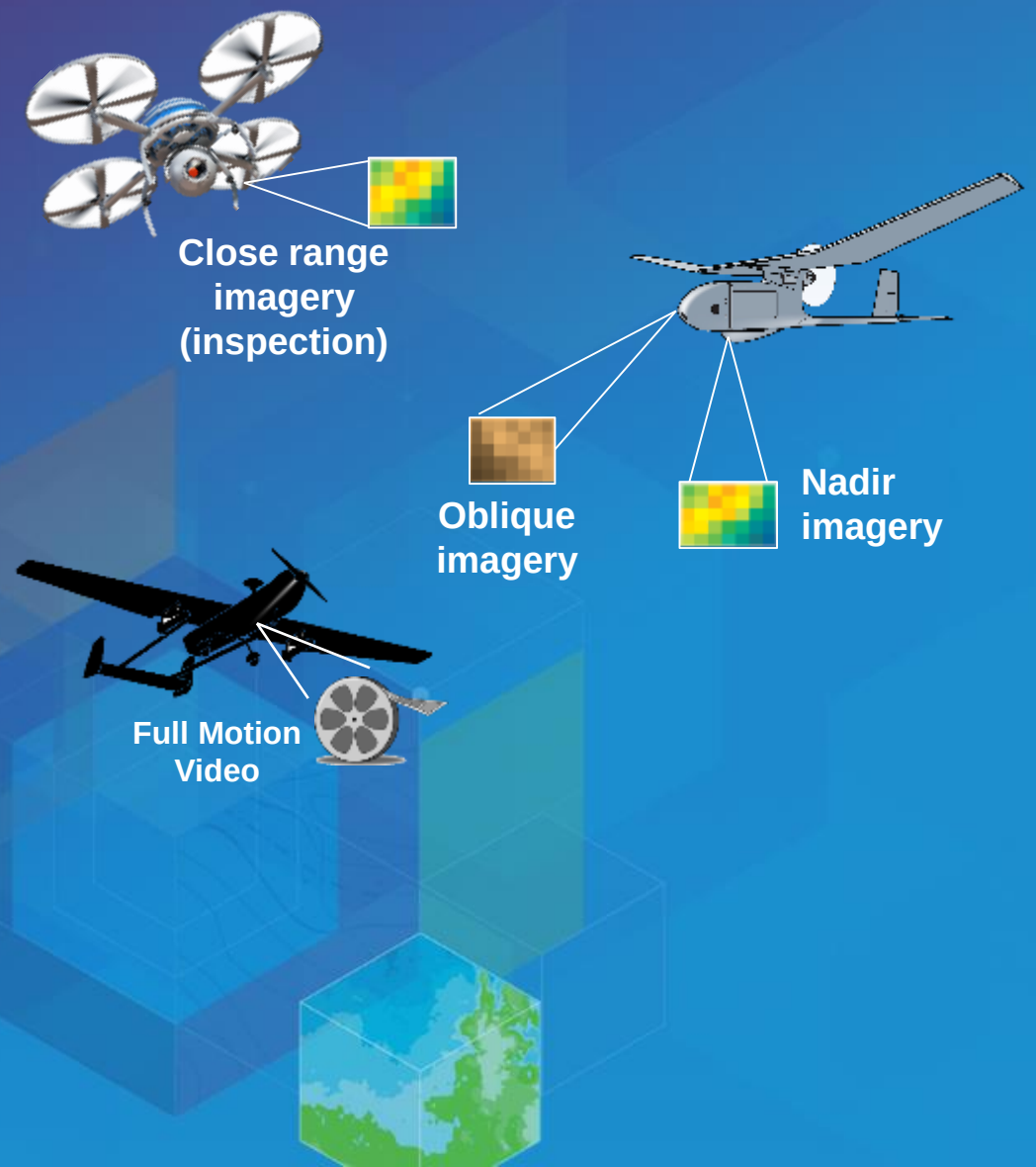
- Frame camera mosaic dataset is oblique aware
  - Sensor Azimuth - indicate camera horizontal direction (0 ~ 360)
  - Sensor Elevation – indicate camera vertical direction (0 ~ 90)
- Query these value to determine
  - Whether a image is oblique
  - The image's look angle
- New Web Appbuilder "Oblique Viewer" widget
  - Create comprehensive web app to view oblique images from frame camera image service
  - Perform mensuration

Sensor Azimuth	Sensor Elevation
358.63081	89.932621
11.414397	89.929006
357.567056	89.924382
10.65224	89.933026
349.311434	89.933089
358.810121	89.904169
12.167622	89.917067
357.734182	89.917796
8.229158	89.915742
1.35762	89.911365
359.515553	89.916027

Alternative workflow for UAV projects

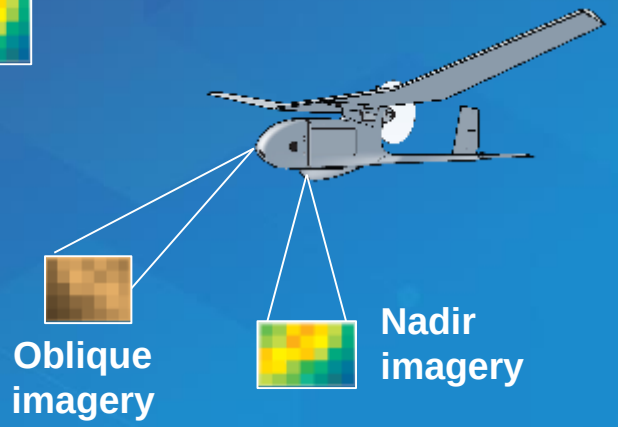
Data Management of single frame images as well as orthomosaics and DSMs

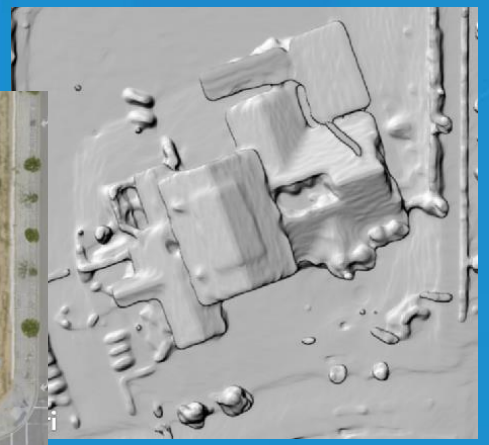
Imaging modes and data: UAV data collection



- **Single image frames**
  - Geotagged, or may include full orientation metadata
  - May be nadir or oblique (low / high)
- **Aerial video**
  - Typically geotagged (GPS only)
  - May have MISB (orientation) metadata

Data Products from UAV data collection (imagery based)





- Orthorectified mosaic
- Digital Surface Model (DSM)
- Orientation metadata (nadir/oblique)
  - Multiple view angles
- 3D point clouds
- 3D models

Automated workflow for Drone2Map (and similar) projects

- Organize Orthorectified Mosaic, Digital Surface Model, and Oriented Frames into Mosaic Datasets (single project)
- Compile multiple projects into a managed collection
- Based on the Image Management Workflows

Demo

Automated workflow for management of Drone2Map products

For full motion video from UAV (drone)

- Refer to another presentation at UC 2016:

Drones in ArcGIS

Thu 30, 1:30 PM – 2:45 PM

Room 14 A

Summary – and links to further information

Best Practice Workflows for Image Management

Our focus was on creating the mosaic dataset for a single data collection using the *Frame Camera* Raster Type…

For more info re: data management & automation:

- **Resource Center landing page** http://esriurl.com/6005
- **Guidebook in Help System** http://esriurl.com/6007
- **ArcGIS Online Group** http://esriurl.com/6539
  - Downloadable scripts & sample data
- **Recorded webinar:** http://esriurl.com/LTSImgMgmt