Boise N.F. Lessons Learned

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2008 USDA Imagery Planning Meeting
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Topics

- Flight Planning
- Image File Naming
- Photo Center File
- Color Bit Depth
- Color Band Order
- Image Rotation
- Inertial Measurement Unit
- Camera Calibration Report

Topics not discussed

- Delivery media
- Provisioning/distribution
- Long-term storage

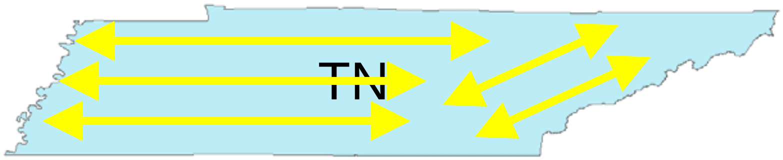
Flight Planning Background

- Traditional film acquisition had well established flight planning process
  - 9-inch squared aerial film
  - North-south flights
  - Footprint was based on film scale
  - Endlap: 62%; Sidelap: 30%
- APFO flight planned and provided exposure stations with contract

Flight Planning (Con't)
Direct-digital Cameras

- Government cannot "flight plan"
  - Each camera has unique footprint
  - Camera not known until after award
- Flight planning requirement passed to contractor
  - Allows coverage optimization (based on aircraft, terrain, weather patterns, etc)

Example: 2008 NAIP



Flight Planning (Con't)
Direct-digital Camera Footprints

DMC	UltraCamXp	ADS-80
7,680 x 13,824	11,310 x 17,310	12,000 line
120mm/25mm	100mm/33mm	64° FOV

Flight Planning (Con't)
Lesson Learned

- Boise project required contractor to submit flight plan for approval
  - Due to the extreme terrain, originally planned for 80%/56% (block D)
  - Reduced to 72%/43%
  - Extra coverage increased acquisition risk and file sizes
- Sidelap/Endlap significantly impacts file sizes

Image File Naming Background

- Original naming convention
  <project code> _<image number>_<yyyymmdd>.tif
  project code = project code
  image number = consecutively numbered value
  yymmdd = image exposure date

  Example: 614020_00001_20080827.tif

- Mod 2 naming convention
  <project code>_<flt line no>_<exp no>_<yyyymmdd>.tif
  project code = project code
  flt line no = flight line number
  exp no = consecutively numbered value
  yyyymmdd = image exposure date

  Example: 614020_0025_0001_20080827.tif

Image File Naming (Con't)
Lesson Learned

- Predetermined stations not possible
  - Each direct-digital system has different footprint
- Need a way to index back to location
- Consistency is needed within project
  - Photo Center File numbers must match
- Only one file allowed per "station"

Photo Center File
Film-based Acquisition

DESCRIPTION	MAXIMUM NUMBER OF CHARACTERS IN FIELD
Project Identification Code	6
Flight Line Number*	4
Exposure Number*	4
Date of Exposure	8
Time of Exposure – Local 24 Hour Clock	6
Sensor Serial Number **	15
Latitude (DD.DDDDD)	8
Longitude (-DDD.DDDDD (Negative))	10
Flight Altitude in meters at camera	8

*Same flight line and image numbers used for file naming convention.

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±30m accuracy

Photo Center File (Con't) Direct-Digital

DESCRIPTION	MAXIMUM NUMBER OF CHARACTERS IN FIELD
Project Identification Code	6
Flight Line Number*	4
Exposure Number*	4
Date of Exposure	8
Time of Exposure – Local 24 Hour Clock	6
Sensor Serial Number **	15
Latitude (DD.DDDDD)	8
Longitude (-DDD.DDDDD (Negative))	10
Flight Altitude in meters at camera	8
Number of GPS Satellites Acquired	**2**
Position Dilution of Precision (PDOP)	**3**
IMU omega value (Radians)	**10**
IMU phi value (Radians)	**10**
IMU kappa value (Radians)	**10**

±5m accuracy

***Same flight line and image numbers used for file naming convention.**

****If digital camera has more than one sensor head please use the camera serial number.**

Example:

614020,25,1,20080827,130755,12345678,42.71936,-23.41498,7048.63,5,1.5,.0001358,.01073000,-.8732658

Photo Center File (Con't)
Lesson Learned

- PCF is critical for spatial positioning
- GPS/IMU data needed
- 5-decimal place lat/lon is only accuracy to approximately 1m

Color Bit Depth Background

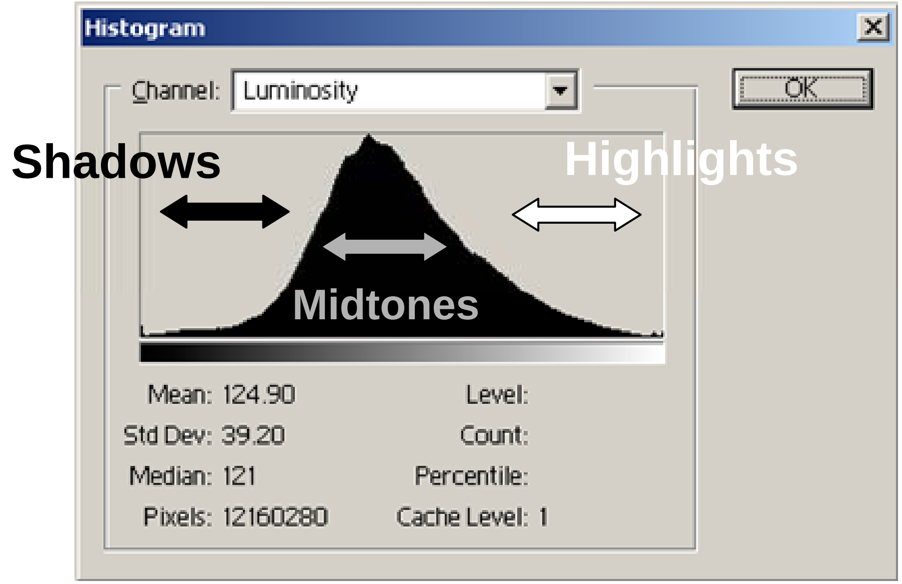
- Most digital cameras acquire imagery at 12 or 14-bits per color
- Graphic file formats use bytes (8-bits) to store each pixel color
- Bit depth determines the number of possible “shades” per color
  - 256 shades for 8-bit (2^8)
  - 65,536 shades for 16-bit (2^16)

Color Bit Depth (Con't)
GIS vs Remote Sensing

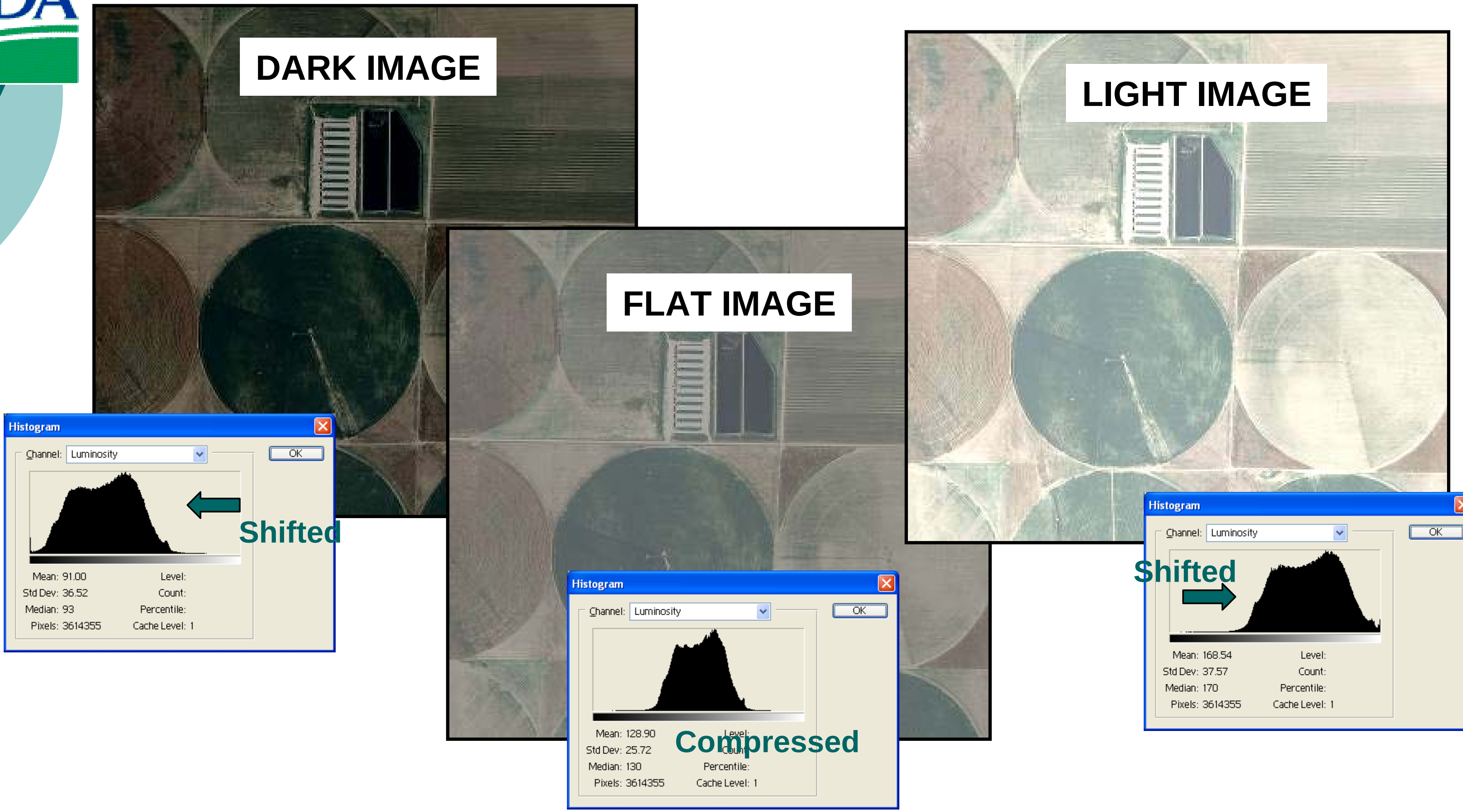
- GIS users:
  - Want "pretty picture"
  - 8-bit, color balanced image
- Remote Sensing users:
  - Want unmodified radiometric data
  - No data loss
  - 16-bit, unstretched image
- Contradictory needs

Color Bit Depth (Con't) Histogram Basics

A graph showing the relative distribution of various tonal values in an image. The histogram shows the number of "dark" values on the left and "bright" values on the right. Its purpose is to show the distribution of tone throughout an image.

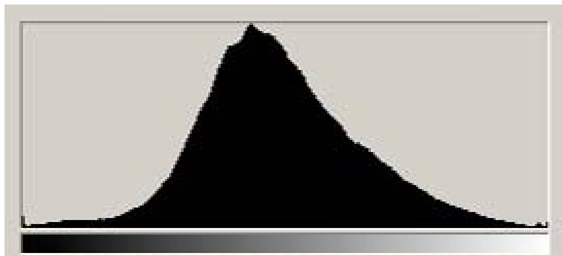


Color Bit Depth (Con’t) Histogram Examples

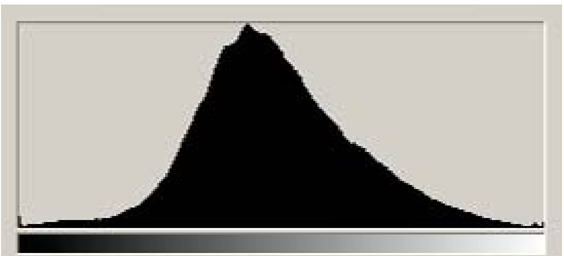


Color Bit Depth (Con't)
12-bit Storage in 16-bit File Format

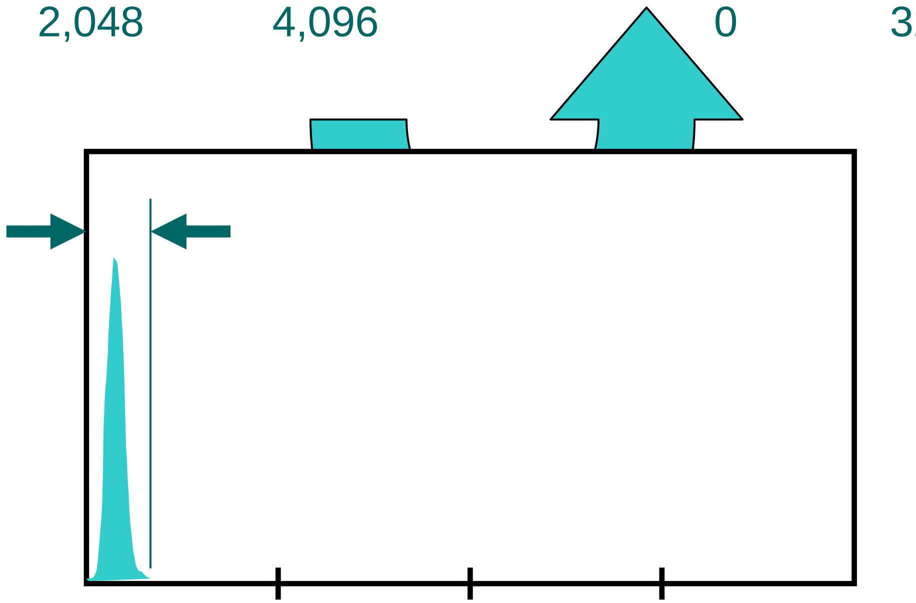
12-bit:



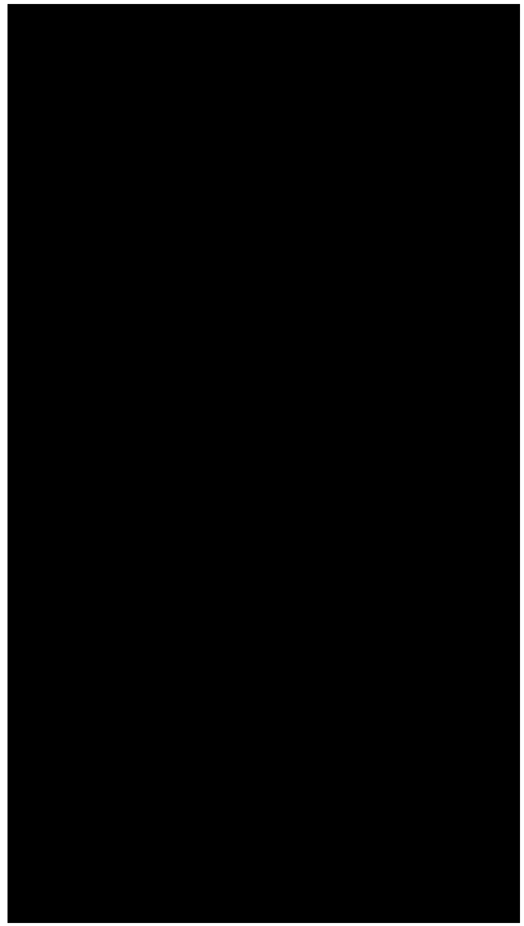
16-bit:



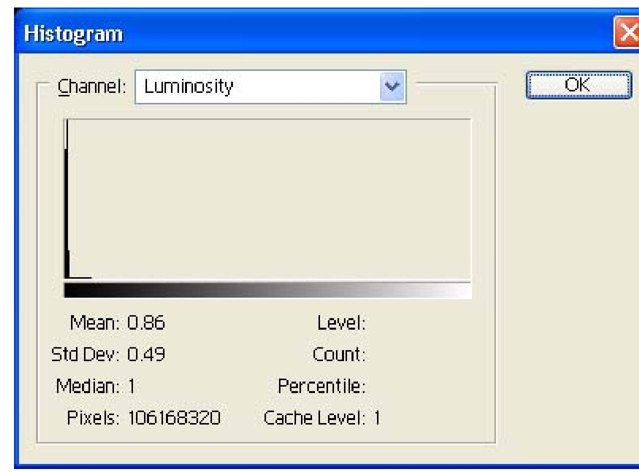
Approx 6%



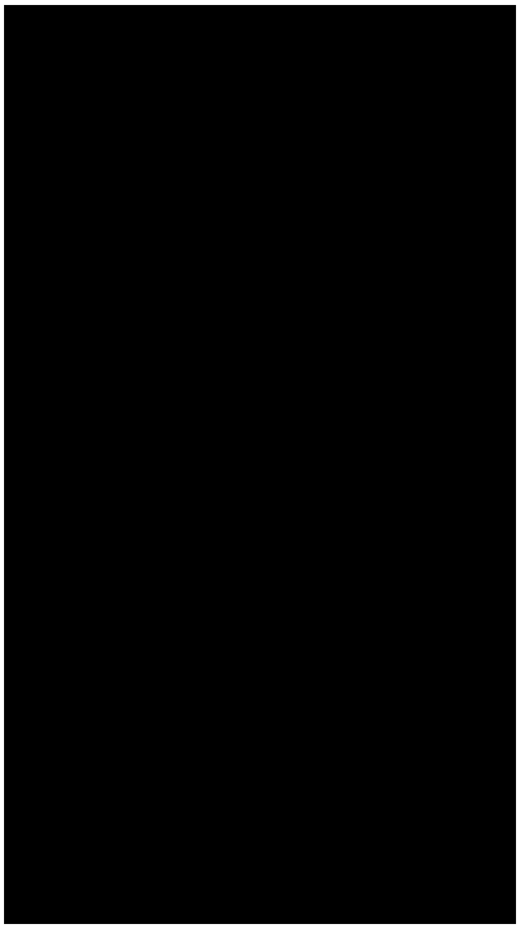
Color Bit Depth (Con’t) Unstretched Image



Unadjusted Boise NF image displayed in ArcMap

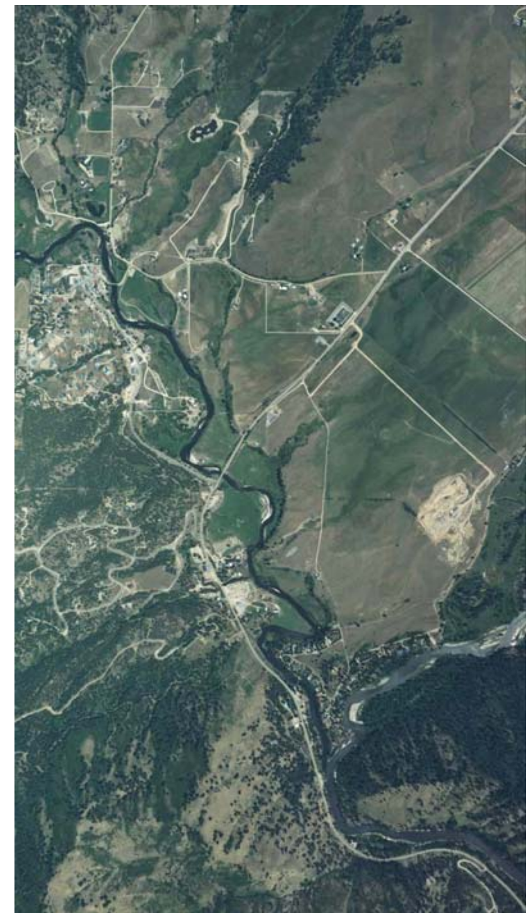


Color Bit Depth (Con’t)
Histogram Stretching

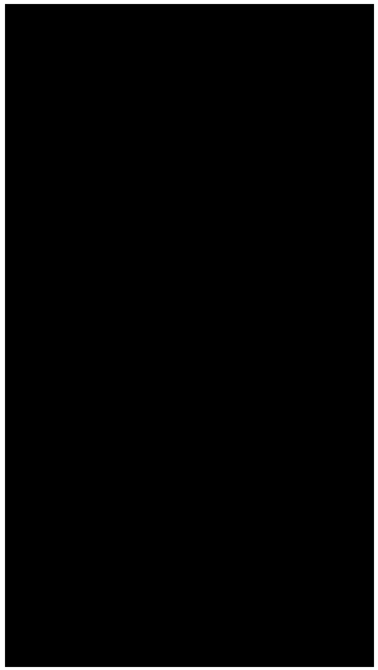


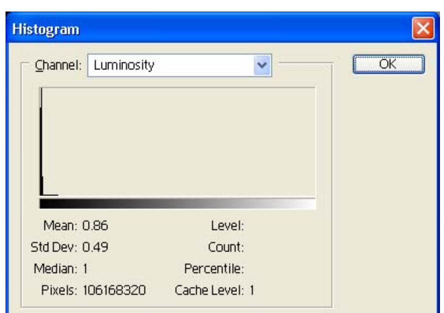
Stretch

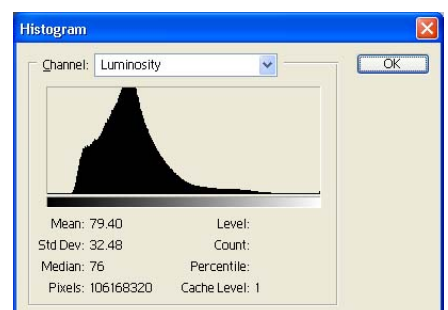
(LUT)



Color Bit Depth (Con't)
Histogram Comparison



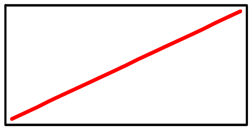




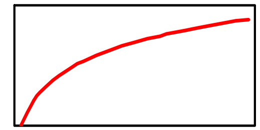
Color Bit Depth (Con't)
Image Options

- Do nothing
  - ArcMap does not automatically apply histogram stretch
- Pre-stretch histogram
  - Stretching is irreversible
  - Data loss may impact RS users
- Create an "AUX" file
  - Contains statistic information

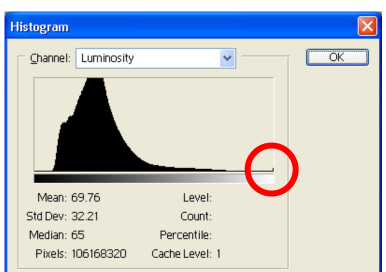
Color Bit Depth (Con't) Histogram Stretching

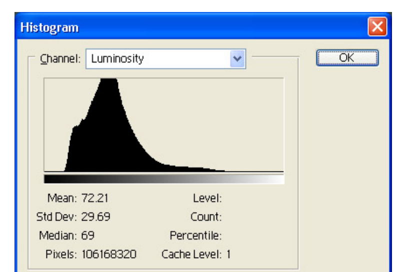


Linear



Non-linear





Color Bit Depth (Con't) Lesson Learned

- Unprocessed imaging will look "black" without stretching
- AUX file will resolve issue in ArcMap
- More than one method of "stretching" histogram
- Users need to be educated

Image Rotation
Sensor Attitude

Source: Aero-Metric

- Long dimension of image is flown parallel with a/c wings
- Reduces number of flight lines (lowers acq cost and risk)
- “Upper left” corner of image may not be the northwest point

Image Rotation(Con’t)
North-South Flight Lines

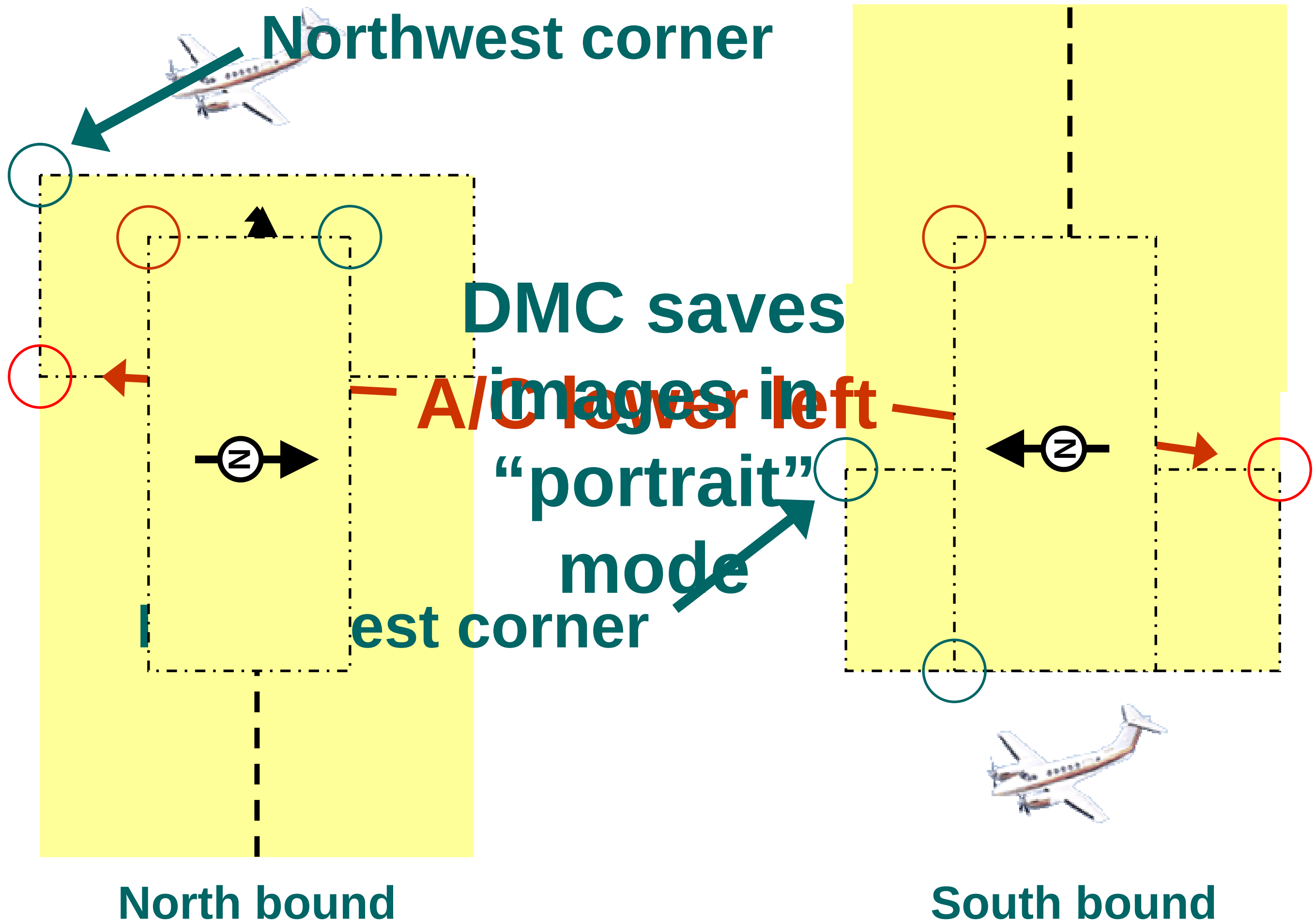
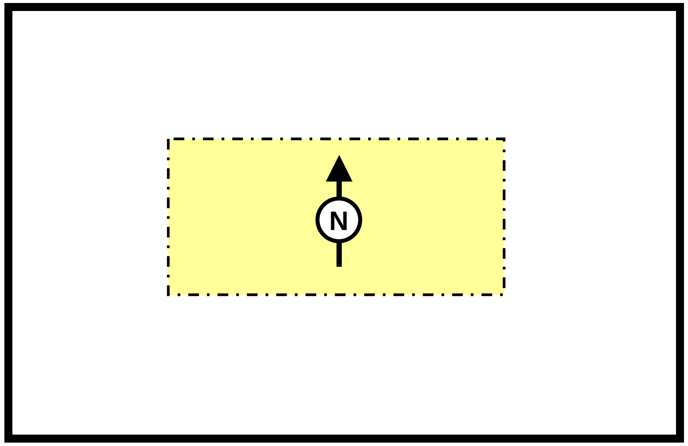
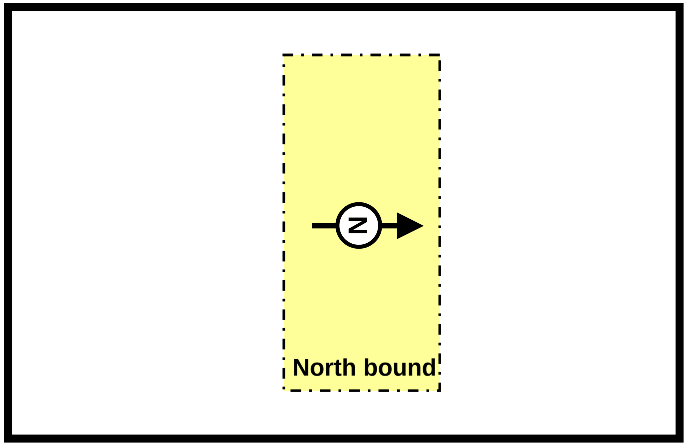


Image Rotation(Con't)
Importing Unprocessed Imagery

- RS software will not "auto" rotate image using the GeoTIFF/TFW rotation information



ArcMap



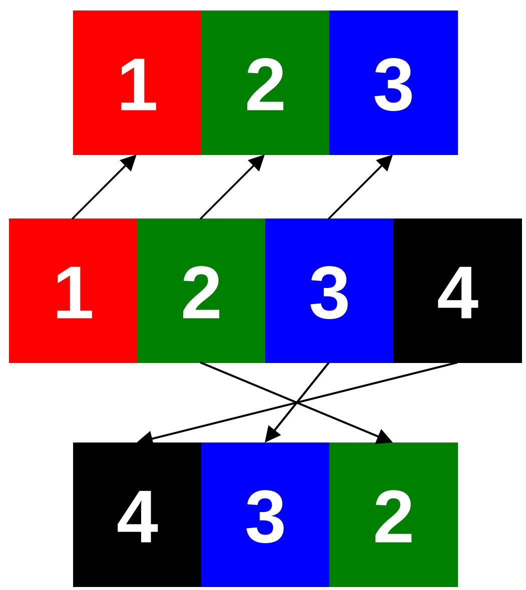
Socet Set

Image Rotation(Con't) Lesson Learned

- RS software requires applying the GPS/IMU data to display north up
- Cannot "flip" image because correct image/IMU orientation would be lost
- End users will have to understand that each camera manufacturer may save image data differently

Color Band Order
Displaying Multispectral Imagery

- Remote sensing software assumes ”satellite” band order when opening multispectral imagery

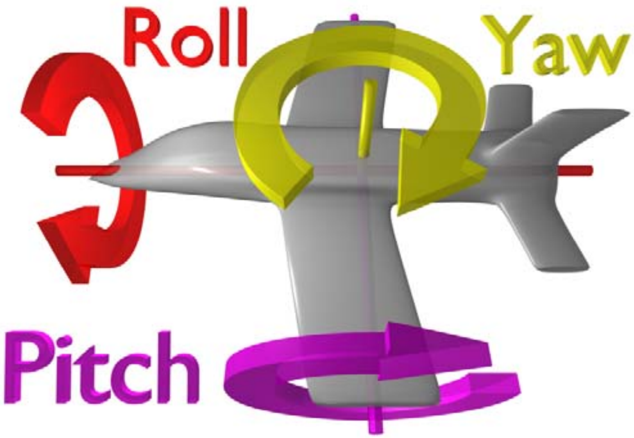


Color Band Order (Con't) Lesson Learned

- No issue with 3-band imagery
- GIS software applications act consistently with photographic applications
- One set of users will have to adapt
  - RS users are more "experienced" with band order
- Long-term consistency is important

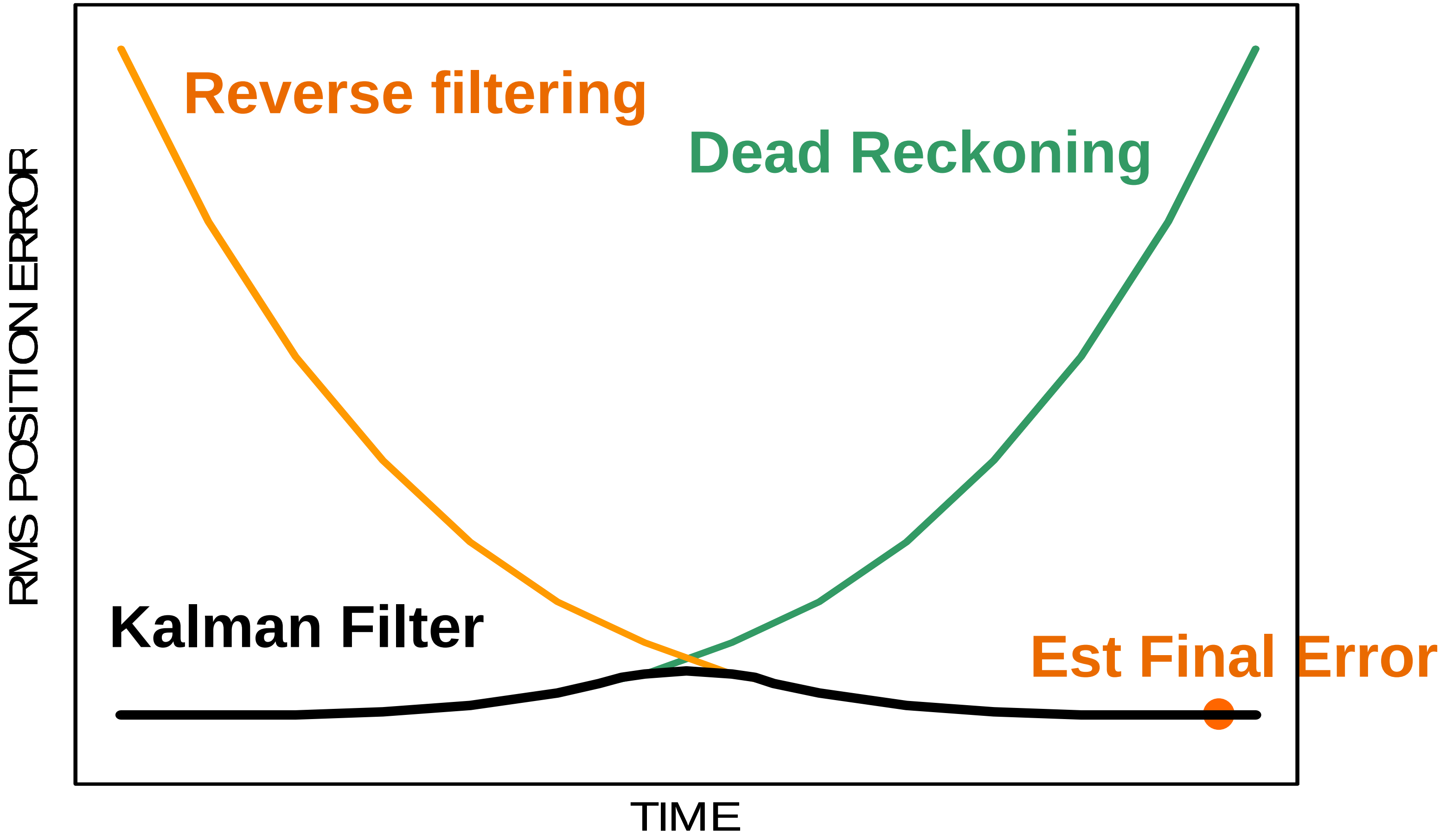
Inertial Measurement Unit General Concept

- An IMU works by detecting the current rate of acceleration, as well as changes in rotational attributes, including pitch, roll and yaw. This data is then fed into a computer, which calculates the current speed and position, given a known initial speed and position
- A major disadvantage of IMUs is that they typically suffer from accumulated error.



Source: www.wikipedia.com

Inertial Measurement Unit (Con't)
IMU Errors

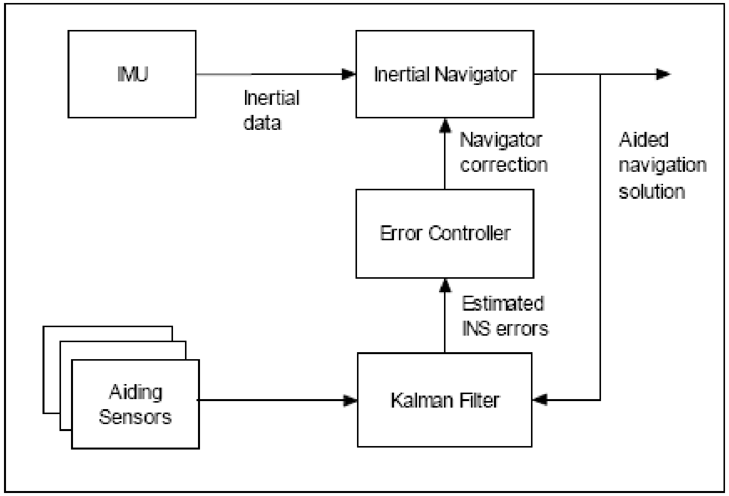


Inertial Measurement Unit (Con't) Differential GPS vs IMU

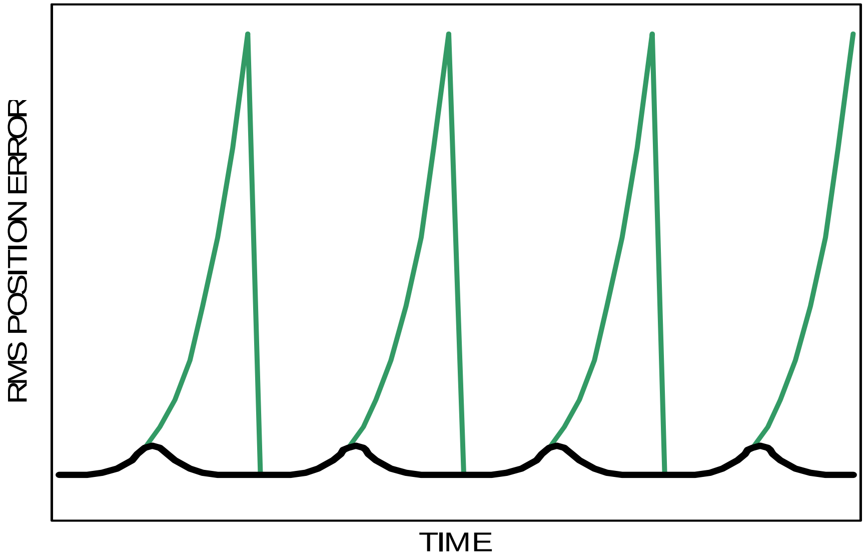
	Advantage	Disadvantages
DGPS	• High accuracy of position and velocity estimation • Time-independent error model	• Low bandwidth • Satellite shading (dropouts) • Slow ambiguity resolution
IMU	• Full 6 DOF solution • Continuous data acquisition • Self-contained (no dropouts)	• Drift - solution errors grow over time
INS / DGPS	• Combine all advantages of both systems • Redundant and complementary data (both systems' errors are separately observable) • Navigation through GPS outages • GPS fixes allow INS error estimation	• No significant limitations

Inertial Measurement Unit (Con't) Combining IMU & ABGPS

- Inertial navigation system starts from a known position (i.e. airport)
- Current position is updated by IMU
- Drift error is corrected with GPS
- Post-processed for backward solution



Source: Applanix Corp



Inertial Measurement Unit (Con't) Lesson Learned

- Must rely on contractor's to accurately post-process data
  - No method for inspecting accuracy
  - CORS/Base stations impact accuracy
- Processed GPS/IMU data very important for ortho production
- No industry standard for text data
  - Contract specification will have to state what software end user is using

Camera Calibration Report
Lesson Learned

- No report similar to film-based USGS camera calibration report
- Must rely on manufacturer's calibration report
- No "fiducial marks"
- Frame-based cameras have multiple sensors
  - DMC has 8 sensors/2 lens lengths

Summary

- Intended use of imagery significantly drive requirements
- Need to standardize products for consistency
- End users need basic level of education

Questions