Aerial Mapping Systems
Aerial Photogrammetry

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GIS Group April 19, 2005
History of Photogrammetry

- 1038 Camera obscura
- 1727 Silver salts
- 1782 Montgolfier Brothers
History of Photogrammetry

- 1903 Wright Brothers control mobility
- 1913 first aerial maps
- Photogrammetry was born
Types of Photogrammetry

- Aerial Photography
- Terrestrial Photography
- Close Range Photography
Radiant Waves

Visible Light

- Blue
- Green
- Red
Structure of Aerial Film Panchromatic
Structure of Aerial Film Color

- blue
- filter
- green
- red

film base

antihalation backing
**FIGURE 11.** Film processing functions.
Grab and Tilt

FIGURE 26. Crab.
Overview of Photogrammetry
Focal Length
Flying Height

Relief Displacement
Overview of Photogrammetry

- 30% Sidelap & 60% overlap
Overview of Photogrammetry

- Stereo Plotters
  - Analytical
  - Analog
  - Softcopy
Photogrammetry Products

- **DTM**
  - Grid
  - Breaklines
  - Contours, 90% \( \frac{1}{2} \text{ contour} \) (NMAS)
  - Spot Elevation, 90% \( \frac{1}{4} \text{ contour} \) (NMAS)

- **Planimetrics**

- **Orthorectified Imagery**
Overview of LiDAR

- **LiDAR** - Light Detection and Ranging
  - Push Broom Laser Scan
  - 25000 pts/sec

- **Airborne GPS**
  - 5-10 cm – Reality 15 cm

- **IMU** - Inertial Measurement Unit
  - 1 degree
  - 1/3000th flying height 1’-2’
Overview of LiDAR

Filtering

- Multiple Returns
  - Buildings
  - Vegetation
  - Bare Earth
■ Quality Control
  • At least 3 Ground Stations
    – Within 10 km
  • Some ground control

■ Quality Assurance
  • Should have spot check
  • Should have cross section checks
LiDAR Product

**Pros**

- 20% the cost of photogrammetry
- Deliveries in as little as 30 days
- Minimal Ground Control

**Cons**

- No Planimetrics
- 10-20 times more data
- May contain anomalies
- No minor break detail
- Not a smooth surface
ADS40 Airborne Digital Sensor
Key Factors in choosing ADS40:

- Fast Workflow
- Better Resolution
- Better Color Quality
- Possible Multi-spectral
- Possible Stereo Analyst
IMU integrated in Sensor Head SH40
GPS integrated in Control Unit CU40
FCMS Flight Control Management System (software)
POS Position and Attitude computer integrated in CU40
PAV30 gyro-stabilized mount with attitude control from POS
Airborne ADS40 system

ADS40 System
1. Sensor head SH40 with:
   - Digital optics DO64
   - IMU
2. Control unit CU40 with:
   - position & attitude computer POS
3. Mass Memory MM40
4. Operator interface OI40
5. Guidance Indicator GI40
6. Mount PAV30
Ground sample distance:
GSD ≈ 15 cm / ½ ft

Flying height:
1,500 m / 4,900 ft

Flight direction:

Date: 20 June 2001
Main features of the ADS40

- High area coverage performance (FoV, swath)
- High resolution and accuracy (spatial and radiometric)
- Affordable, application oriented sensors
- Multispectral imagery
- Linear sensor characteristics
- Stereo capability
- Direct digital workflow
Principle of pushbroom scanner ADS40

Differences to film frame camera RC30 and surface array technology
**Terminology**

**Airborne digital sensor**
**ADS40**

- **Example**
  - Pixel on CCD $6.5 \times 6.5 \, \mu \text{m}$
  - Swath 2.4 km
  - Field of view across track FoV 64°
  - Pixel on ground 20x20cm
  - Ground sample distance, GSD 20 cm

**Analog aerial camera**
**RC30**

- **Example**
  - Image size 228 mm x 228 mm
  - Field of view diagonal 90°
  - Focal length 153 mm
  - Footprint 2.4 km x 2.4 km
  - Photo scale 1 : 10,500
Three-line pushbroom scanner

- Backward scene composed of backward view lines
- Nadir scene composed of nadir view lines
- Forward scene composed of forward view lines
Different imaging concepts of ADS40 and RC30

**Airborne digital sensor**
- ADS40
- continuous pushbroom scanning
- forward view
- nadir view
- backward view

**Analog aerial camera**
- RC30
- discrete perspective images
- overlapping aerial photographs
Airborne digital sensor ADS40

All objects recorded 3 times

Analog aerial camera RC30

Not all objects recorded 3 times

Flying with 60% overlap only 50% of all objects are on 3 photographs
Effect of central perspective

Airborne digital sensor
ADS40

Forward view strip

Nadir view strip

Backward view strip

Analog aerial camera
RC30

Photograph with central perspective

Flight line with overlapping photographs
Panchromatic and spectral band filters

Panchromatic backwards
NIR band
Panchromatic nadir
Blue band
Green band
Red band
Panchromatic forward

Panchromatic forward
**ADS40 panchromatic lines - Adria, Italy**

- **Ground sample distance:**
  \[ \text{GSD} \approx 15 \text{ cm} / \frac{1}{2} \text{ ft} \]

- **Flying height:**
  1,500 m / 4,900 ft

- **Flight direction:**

- **Date:** 20 June 2001
Ground sample distance:
GSD ≈ 15 cm / 1/2 ft

Flying height:
1,500 m / 4,900 ft

Flight direction:

Date: 20 June 2001
Blue 430 - 490 nm
Green 535 - 585 nm
Red 610 - 660 nm
Infra-red 835 - 885 nm

Ground sample distance:
GSD ≈ 15 cm / 1/2 ft

Flying height:
1,500 m / 4,900 ft

Flight direction:

Date: 20 June 2001
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GSD ≈ 15 cm / 1/2 ft  

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Date: 20 June 2001
Interference filters
Used in ADS40

Absorption filters
Used in CCD array cameras

Non-overlapping narrow bands

Overlapping bands

Only interference filters are suitable for remote sensing applications where response in non-overlapping narrow bands is evaluated.
Spectral band filters

Legend
1 Grass
2 Lime Stone
3 Sand, dry
4 Snow, old
5 Fir tree
6 Asphalt, wet
7 Water
Dynamic range - data normalization

Dynamic range 8 bit

Resolution steps
- 8 steps
- 16 steps
- 32 steps
- 64 steps
- 256 steps

Resolution Limit of human eyes

Dynamic range of CCD chain of ADS40: 12 bit = 4096 steps

Dynamic range of normalized data: 8 bit = 256 steps

Offset, normalized data and look-up table applied during data normalization are used to restore original data of 12 bit dynamic range
Radiometry

Flying height
9,840 ft / 3,000 m
GSD ≈ 25 cm

Reichstag, Berlin 23 April 1999

Detail in high reflectance area

Detail in low reflectance area
ADS40 Project Workflow
Differing from frame camera technology
Workflow - film based and direct digital

Film based workflow RC30

- Film processing in darkroom
- Films used alternatively
- B&W, Color, FCIR
- Stereo plotter
- DSW500 scanner
- DTM
- Orthophotos
- Mapping
- Revision
- Visualization
- Image analysis
- Classification
- Digital workstation
- Mass Memory
- Ground processing
- Archive system
- Printer
- B&W, Color, MS

Direct digital workflow ADS40

- All spectral channels simultaneously

Workflow - film based and digital
Digital data flow of ground processing

of ADS40 data

Level 0 - Raw data consisting of:
Geometric raw images (TIFF and other formats) and processed orientation data

Level 1 - Rectified data consisting of:
Fully corrected stereo-viewable panchromatic images and fully corrected multispectral images

Level 2 - Geo-coded data consisting of:
Panchromatic and multispectral orthophotos

Digital workstation
Mass Memory
Ground Processing
Archive system
Printer
Level 0 Level 1
Level 2

Spectral channels simultaneously

GIS

DTM
Orthophotos
Mapping
Revision
Visualization
Image analysis
Classification
Rectification of Images from Level 0 to Level 1

Original Scene
(without gyro stabilization)

Roll
Pitch
Yaw

Rectified Scene
Ground sample distance:
GSD ≈ 15 cm / ½ ft

Flying height:
1,500 m / 4,900 ft

Flight direction:

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Date: 20 June 2001
Ground sample distance:
GSD ≈ 15 cm
GSD ≈ 1/2 ft

Flying height:
1,500 m
4,900 ft

Date:
17 April 2001
Imagery
Summary of ADS40 abilities

**Pros**
- Digital Capabilities
- Efficient Digital Workflow
- Multi-spectral Capabilities
- Photogrammetry
- LiDAR integration

**Cons**
- New developing technology
- Limited to 15 cm or 6” resolution
- Minimum Acquisition cost