Luzern, Switzerland, acquired at 5 cm GSD, 2008.

Leica ADS80 - Digital Airborne Imaging Solution
NAIP, Salt Lake City
4 December 2008

Shawn Slade, Doug Flint and Ruedi Wagner
Leica Geosystems AG, Airborne Sensors

- when it has to be right

Leica
Geosystems

1. Our History in Airborne Sensing

- when it has to be **right**

Leica
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Leica's history in aerial photography

C2 - 1925

RC30 - 1992

ADS40 - 2006
SH51 & SH52

ADS40 - 2001

- when it has to be right

Leica
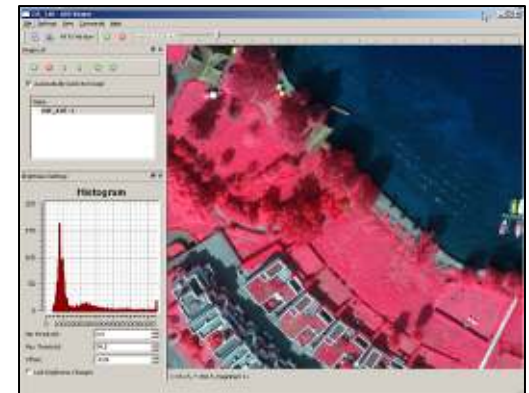*Geosystems*

2008 – Another Milestone
Leica ADS80 (3rd Generation)

SH81 / SH82

+

CU80 / MM80

+

Leica XPro

= *Most <u>complete</u>*
Digital Airborne Imaging Solution

- when it has to be **right**

Leica
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Leica ADS80 – Efficient Data Acquisition
Control Unit CU80 and MM80

- Embedded IPAS20 with GNSS

- High data throughput of 130 MB/sec
  => **More data can be acquired faster (Remote Sensing and Photogrammetry)**

- Radiometric resolution of compressed data 10-bit and 12-bit
  => **Even better data quality**

- Recording interval ≥ 1 ms
  => **Smaller GSD at faster speed**

- when it has to be **right**

Leica
Geosystems

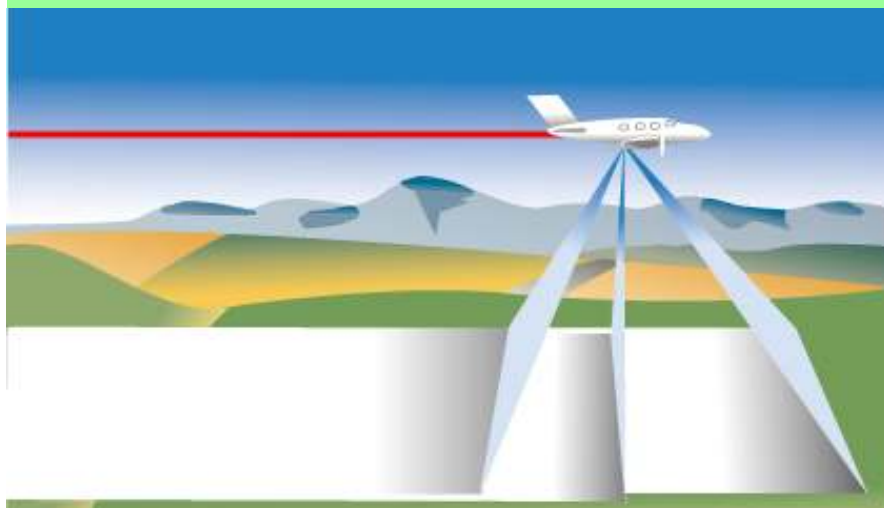# 2. Basic Design Advantages – Why Pushbroom and not Frame?

Different imaging concepts ADS40/80 and RC30

Airborne digital sensor ADS40/80

continuous pushbroom scanning

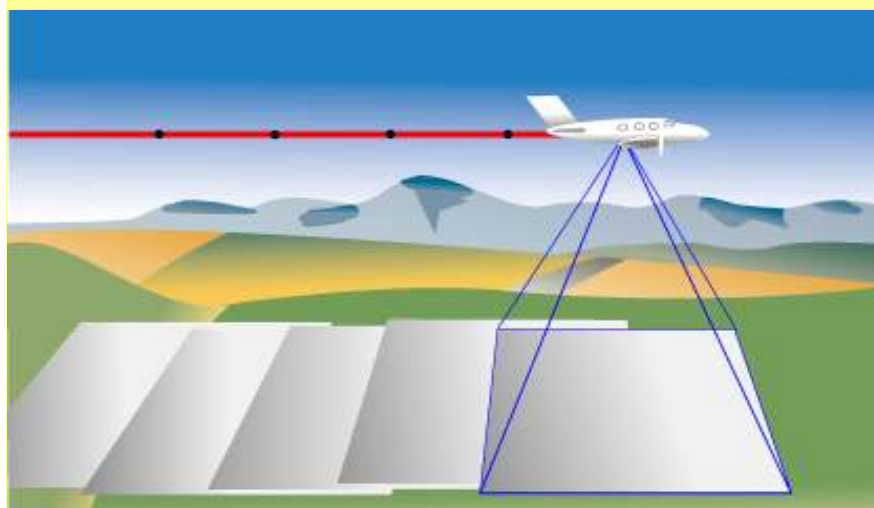forward view

nadir view

backward view

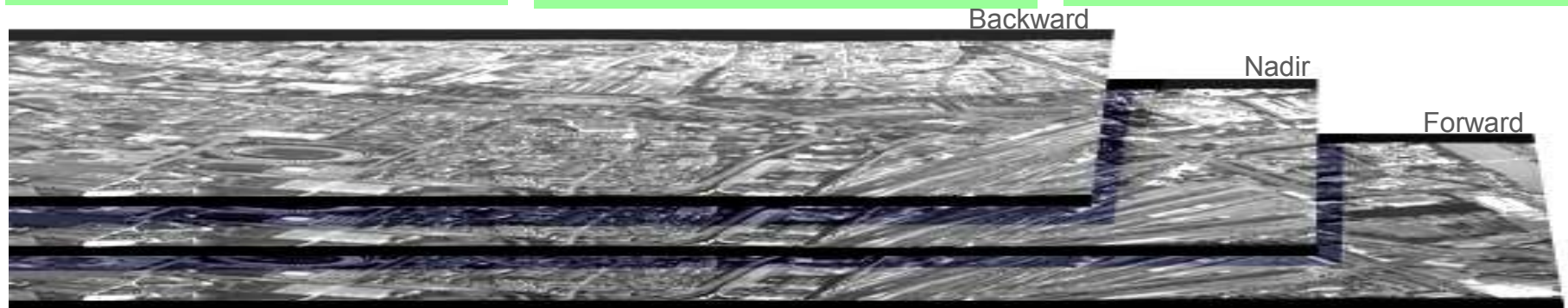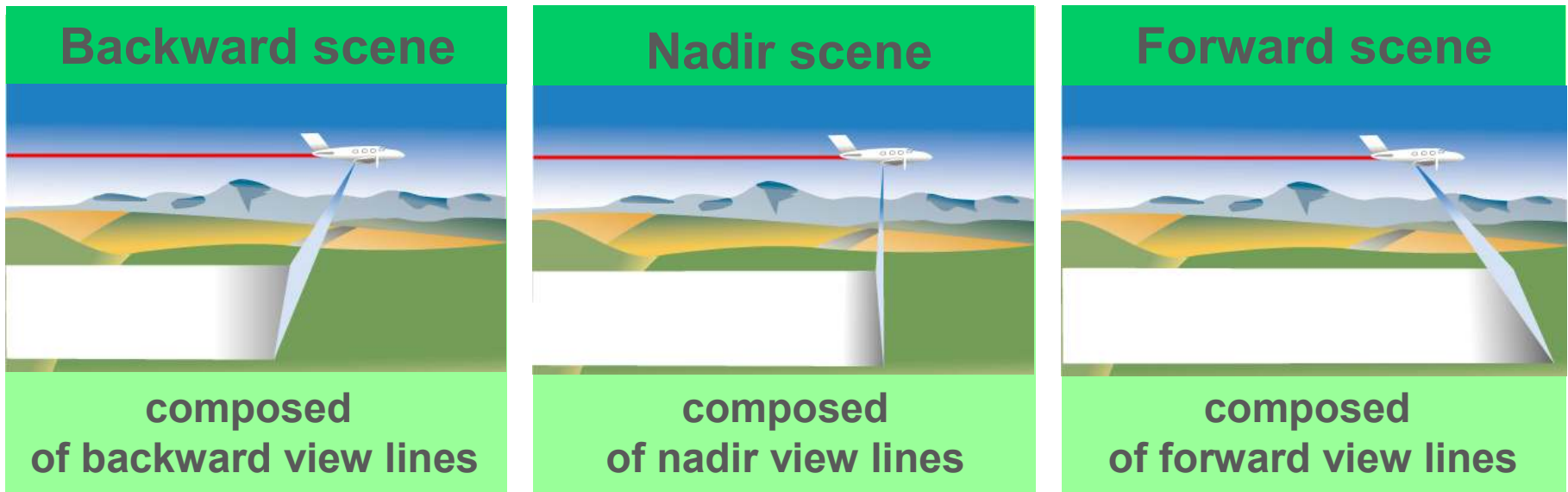**Analog aerial camera RC30**

discrete perspective images

overlapping aerial photographs

- when it has to be **right**

Leica Geosystems

Three-line pushbroom scanner

Backward scene	Nadir scene	Forward scene
composed of backward view lines	composed of nadir view lines	composed of forward view lines

Backward

Nadir

Forward

3 x 100% overlap
Better B/H ratio than digital frame

- when it has to be right

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Geosystems

What is „relevant" to the Customer in aerial digital mapping?
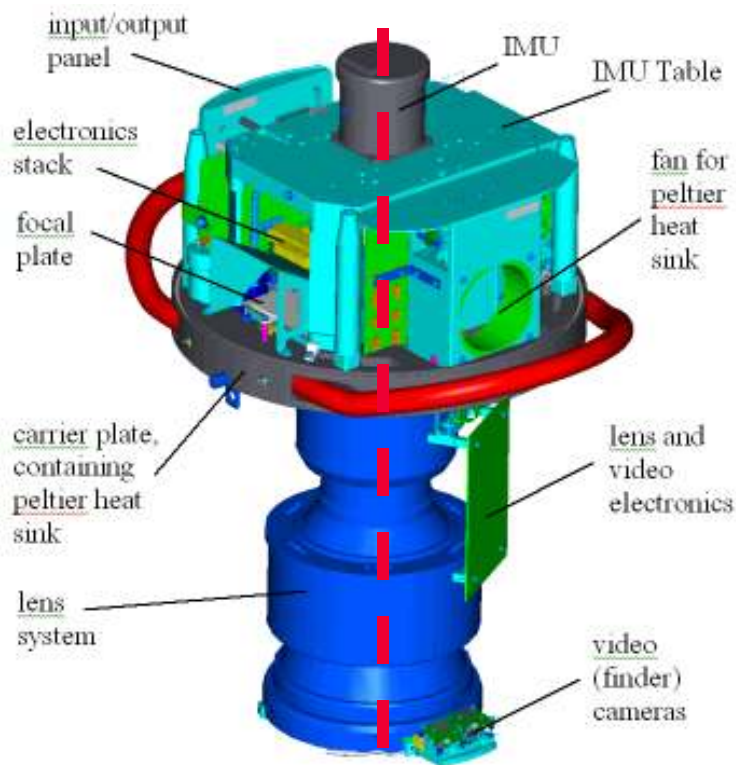
3. Advantages of the Leica ADS80

3.1 Highest Geometric Accuracy

- when it has to be **right**

Leica
Geosystems

Leica ADS40-II/ ADS80
Highest Stability during Data Acquisition

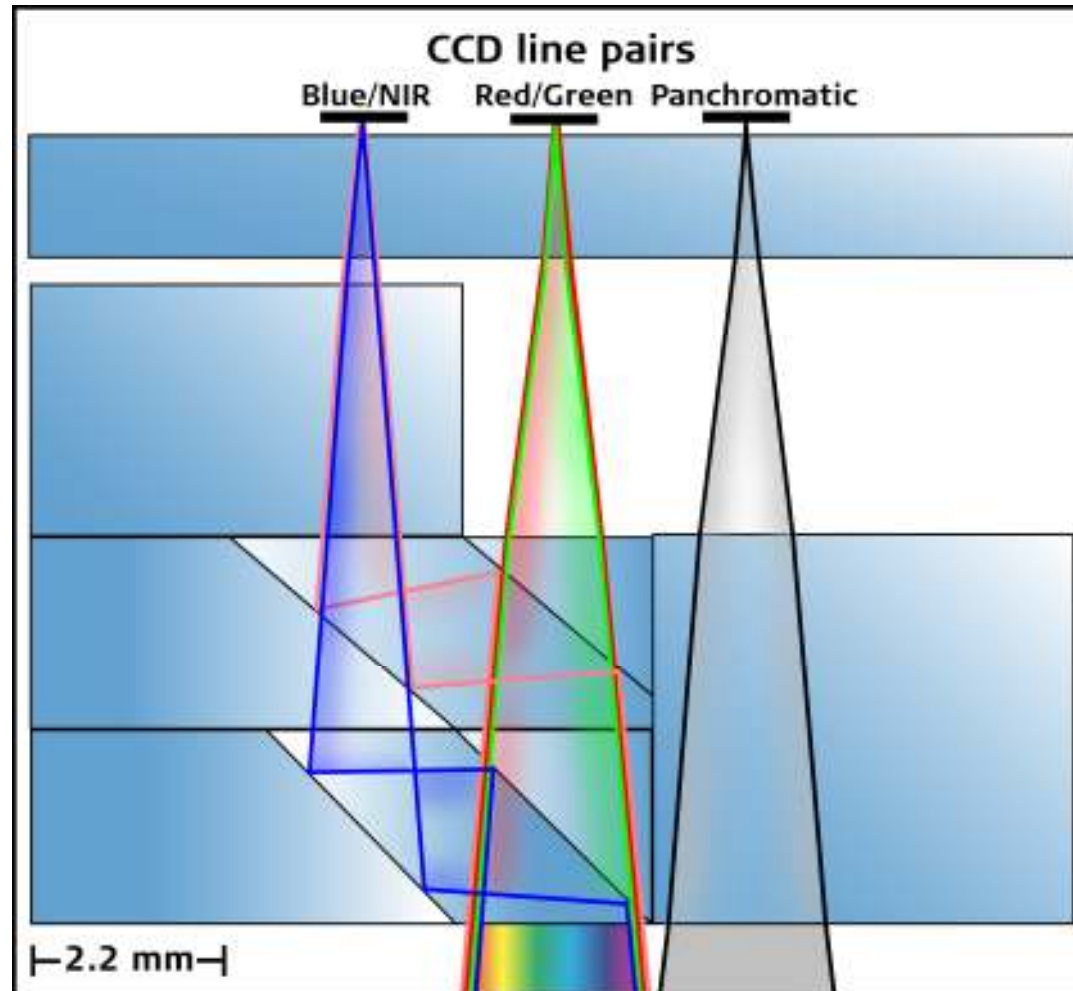- One optical path

- Tight integration

- Very few components

=> Highest Geometric Stability

- when it has to be **right**

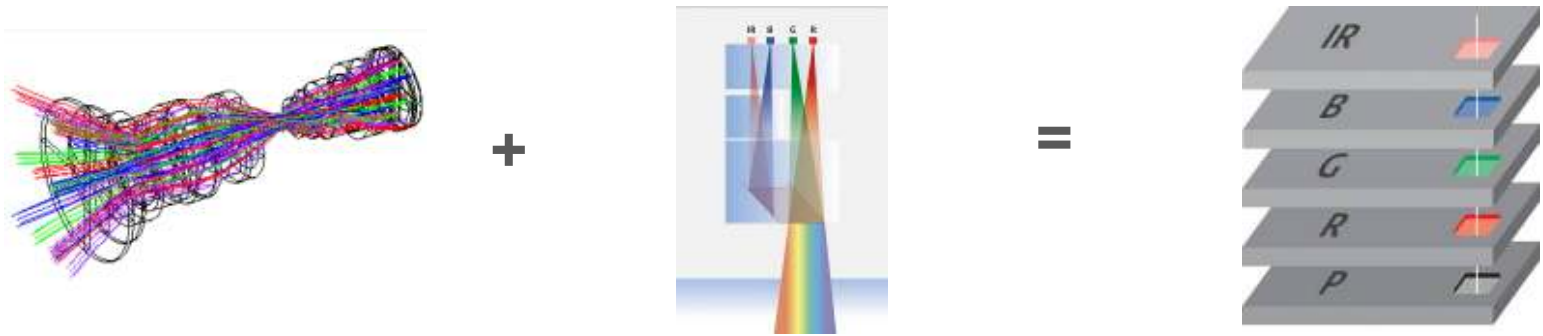**Leica**
Geosystems

Innovative Tetrachroid Beamsplitter
Data Acquisition Efficieny

Leica ADS40-II/ ADS80 - Data Acquisition Efficiency
Equal resolution in all bands

+

=

Telecentric Lens

Thermal and Pressure

Compensated

+

Tetrachroid

=

Equal Resolution

Co-registered in all

bands

NO PAN-SHARPENING

Independent Research shows.......

"The large size digital frame images are merged from 4 separate panchromatic cameras and the color cameras. The image deformation of the sub-cameras, determined by laboratory calibration, is respected by the generation of the homogenous virtual images.

So by theory they should not show any systematic image errors.

In reality an analysis of the image residuals of block adjustments shows very clear systematic image errors corresponding to the merge of the sub-images."

(Passini and Jacobsen, 2008)

- when it has to be **right**

Leica
Geosystems

Quality of external orientation
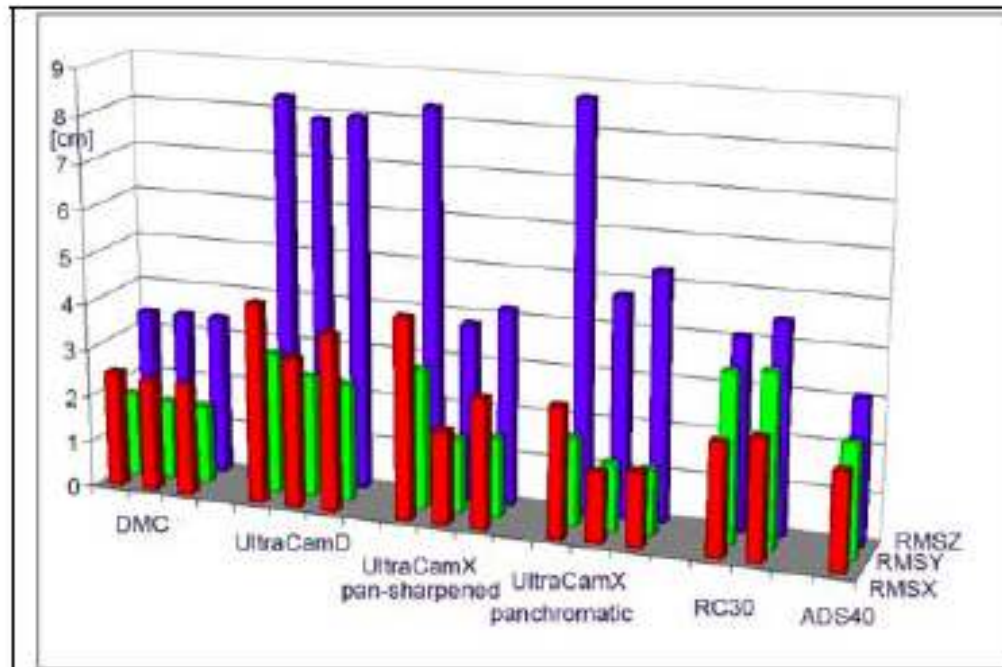## Passini & Jacobsen (2008)

Figure 7. comparison of results at independent check points of block adjustments with 8 control points achieved in test area Franklin Mills based [cm]

Within the groups: from left - without self calibration / with parameters 1 – 12 / with parameters 1 – 12 + camera specific parameters

Frame Cameras flown 60% forward and sidelap
ADS40 flown with 15% sidelap

What is „relevant" to the Customer in aerial digital mapping?

3. Advantages of the Leica ADS80
3.2 Data Acquisition Efficiency

- when it has to be **right**

Leica
Geosystems
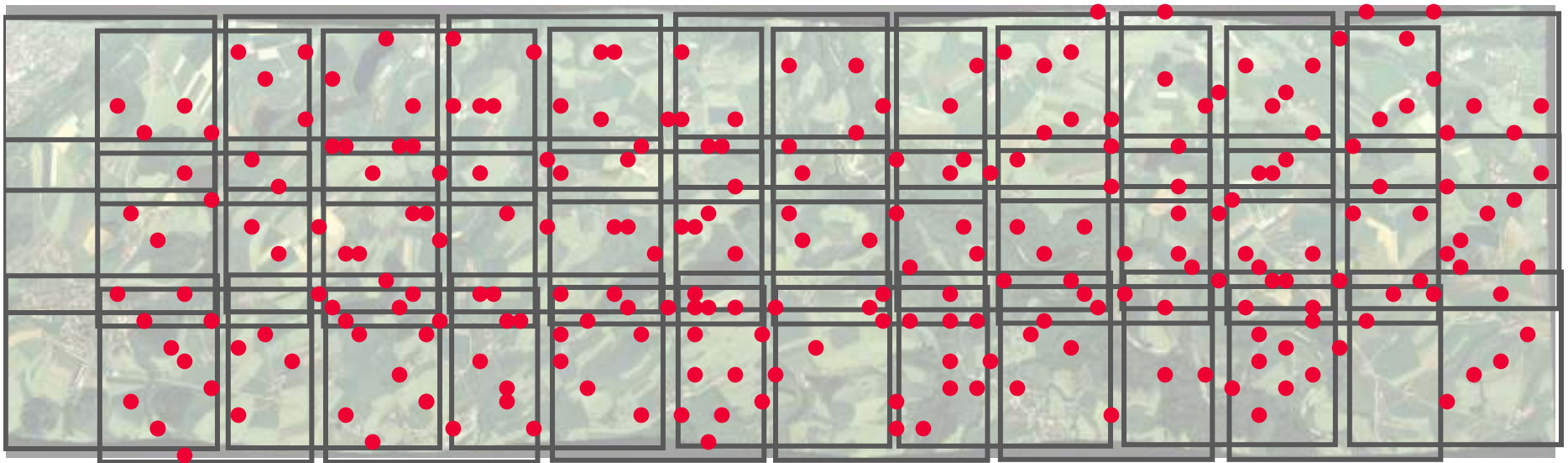
Leica ADS80 – Efficient Data Acquisition

GSD 1.2" / 3 cm   =>   90 kts

GSD   2" / 5 cm   => 140 kts

GSD   3" / 7.5cm   => 190 kts

GSD   4" / 10cm   => 240 kts

GSD   6" / 15cm   => 300 kts

- when it has to be right

Leica
Geosystems

Frame vs Pushbroom in NAIP

- **Requires Creation of Virtual Frames**

- **Requires Pansharpening at ratio 1:3**

- **Minimum 30% sidelap due to AT requirements**

- **Requires 3 tie points per frame – over 240km long strips means 10000s of tie points**

- when it has to be **right**

Leica
Geosystems

Frame vs Pushbroom in NAIP

Digital Pushbroom

- No Mosaicking and colorbalancing of thousands of frames required

- No Pansharpening

- Sidelap can be reduced to <<30%

- Requires 3 tie points between lines (each 240km long)

- when it has to be **right**

Leica
Geosystems

What is „relevant" to the Customer in aerial digital mapping?

3. Advantages of the Leica ADS80
3.3 Highest Radiometric Accuracy

- when it has to be **right**

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Telecentric optics design

Telecentric optics design ADS40/80	Conventional optics design
Vertical incidence of all ray bundles	Vertical incidence only for ray bundle on the optical axis
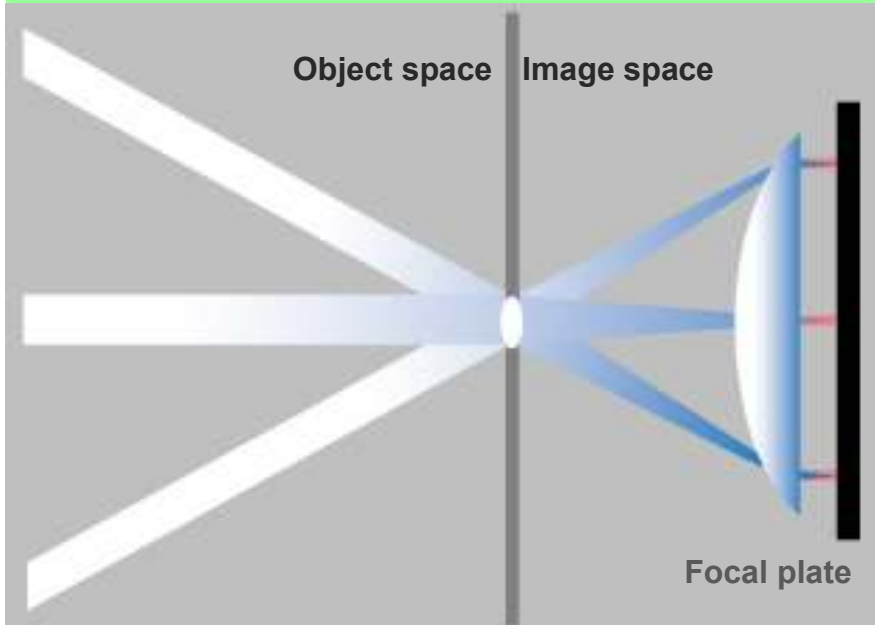
Interference filter and Trichroid/Tetrachroid can be used.
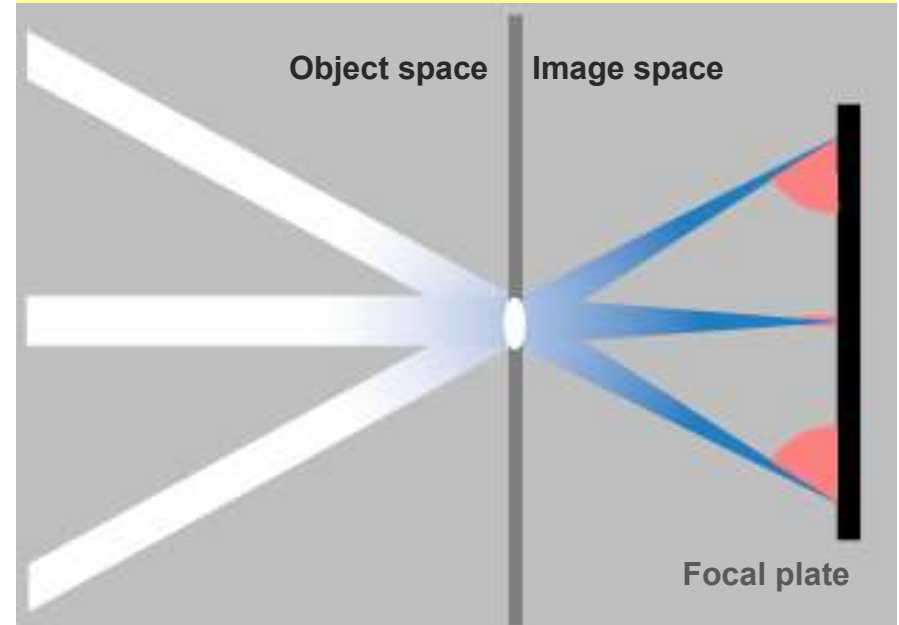
Absorption filters must be used. NOT suitable for remote sensing.

Spectral transmission of interference filters

Telecentric optics design ADS40/80

Interference filter transmission equal across whole FoV

Image space · Red filter transmission · Image red band

Filter · CCD · Swath → · λ→ · Illustration
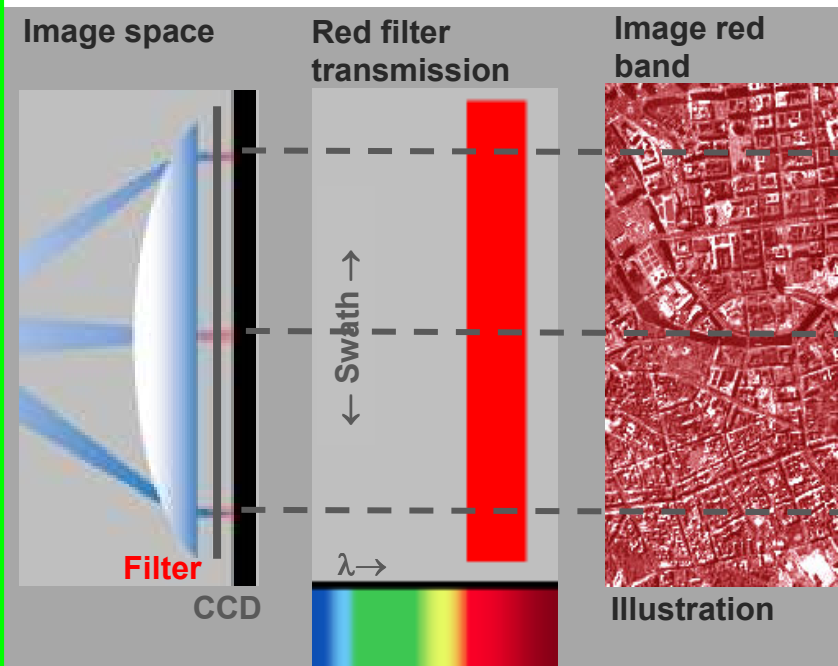
Suitable for remote sensing

Conventional optics design

Interference filter transmission not equal for whole FoV
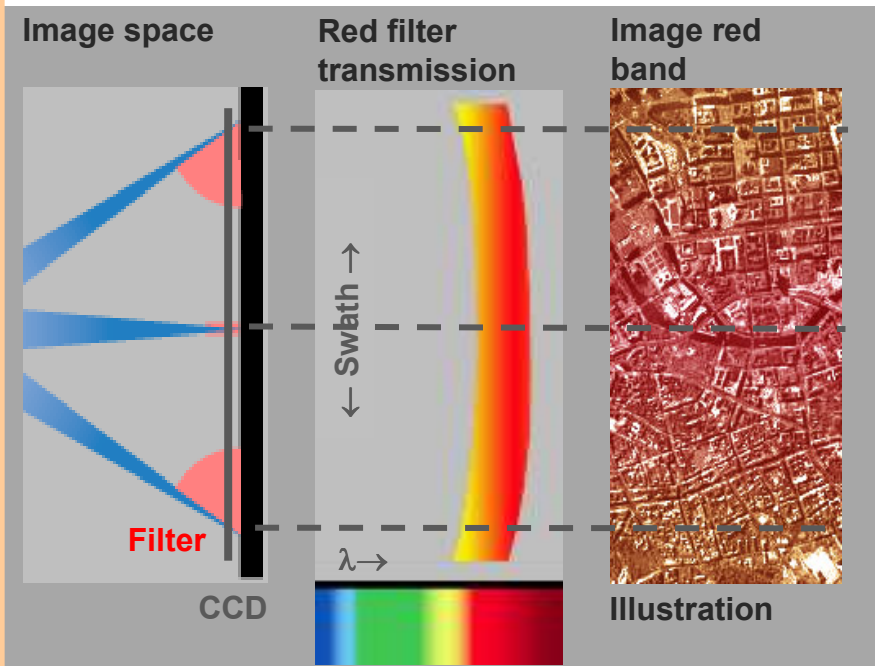
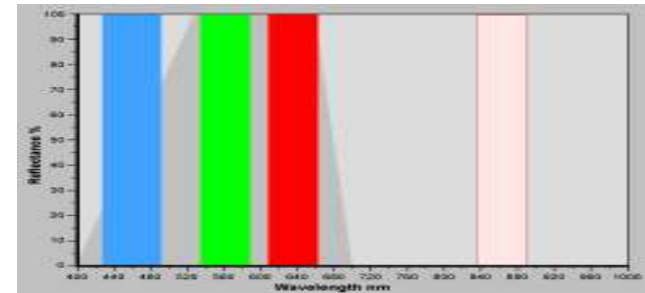Image space · Red filter transmission · Image red band

Filter · CCD · Swath → · λ→ · Illustration

Not suitable for remote sensing

Leica ADS80 – Efficient Data Acquisition Radiometric Accuracy
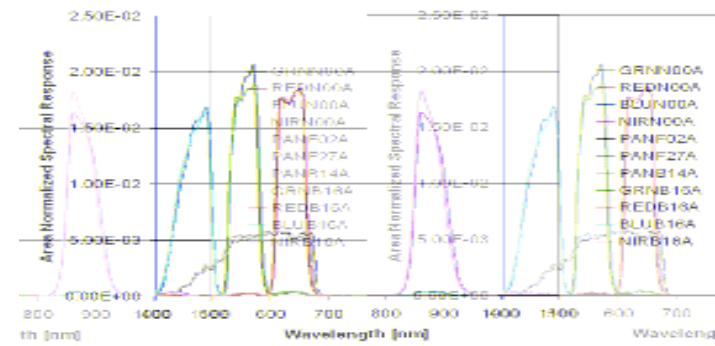
Clearly separated bands, optimized for vegetation

Radiometric Calibration/Performance

„For automated classification, the ADS40 SH52 shows by far the best accuracy." [Kass Green, ASPRS 2008]

- when it has to be **right**

Leica
Geosystems

Tree Type Identification (Waser, 2008)
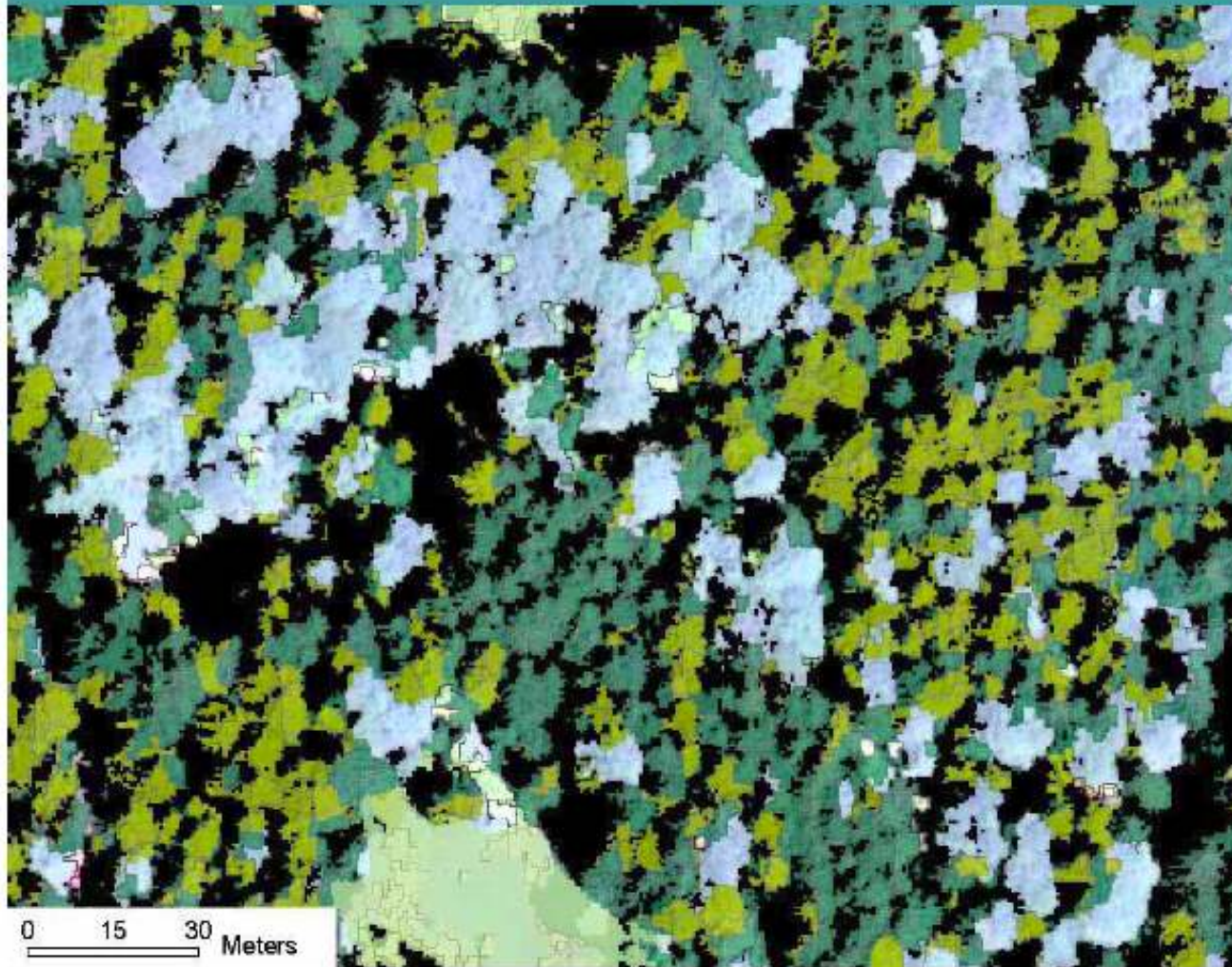
Abies alba

Picea abies

Fagus silv.

Fraxinus exc.

0   15   30 Meters

Geosystems

What is „relevant“ to the Customer in aerial digital mapping?

3. Advantages of the Leica ADS80
3.4 Data Processing Efficiency

- when it has to be **right**

Leica
Geosystems

Leica ADS80 Workflow
Flight Planning and Execution

Flight Planning

FPES – Flight Planning

- Flight Planning
- Flight Plan Optimization
- Project Management
- Cost Estimation

Flight Execution
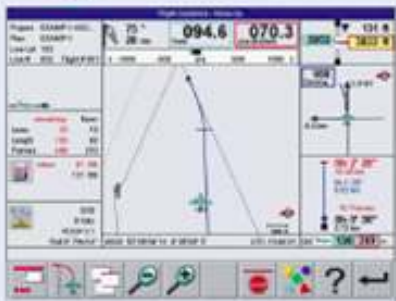
FCMS – Flight & Sensor Control Management

- Guidance Information During Approaches and Turns
- Guidance Information and Sensor Release Along the Line
- Sensor Control
- In-flight Evaluation
- Data Logging and User Log Entries

IPAS20 Inertial Position & Attitude System

- Integrated GNSS/IMU System
- Ensures Direct Georeferencing of Airborne Sensor Data

Mass Memory

Leica ADS80 Workflow
Ground Processing

Leica XPro
- Data Download
- Georeferencing
- Aerial Triangulation
- Image Rectification
- Orthophoto Generation

IPAS Pro
- Post Processing of GNSS/IMU Data
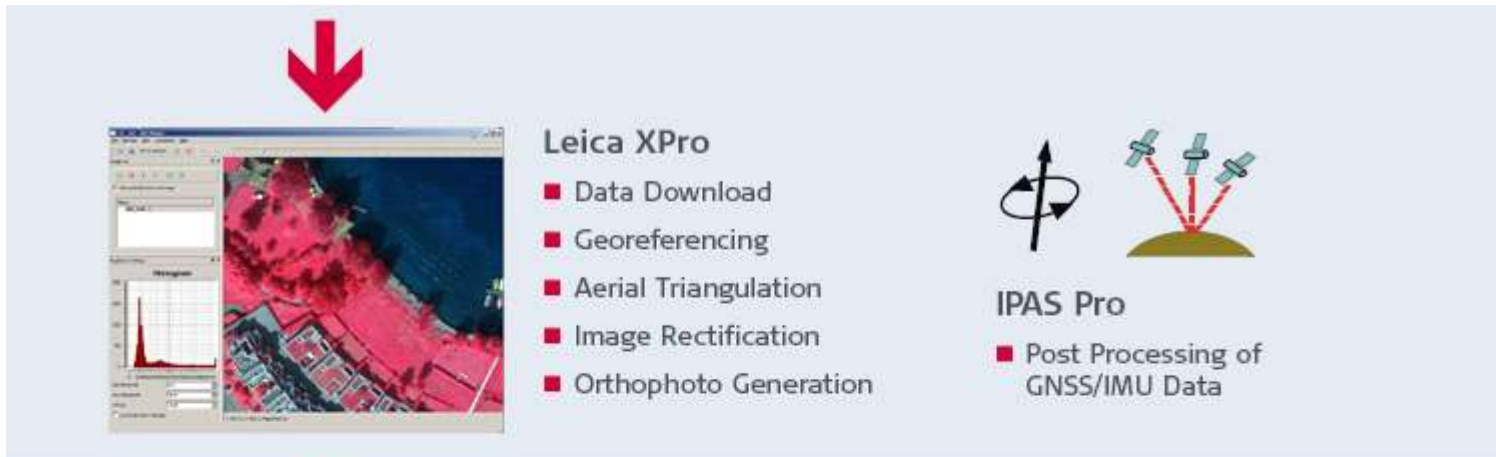
„Processing at the Speed of Flight"

![Leica Geosystems]

Data Processing with Leica XPro
Product Generation

- Radiometric Image Chain implementation throughout the workflow leads to perfect image radiometry - atmospheric haze and bidirectional reflection effects (BRDF) are taken care of

- Full support of 4-band image products
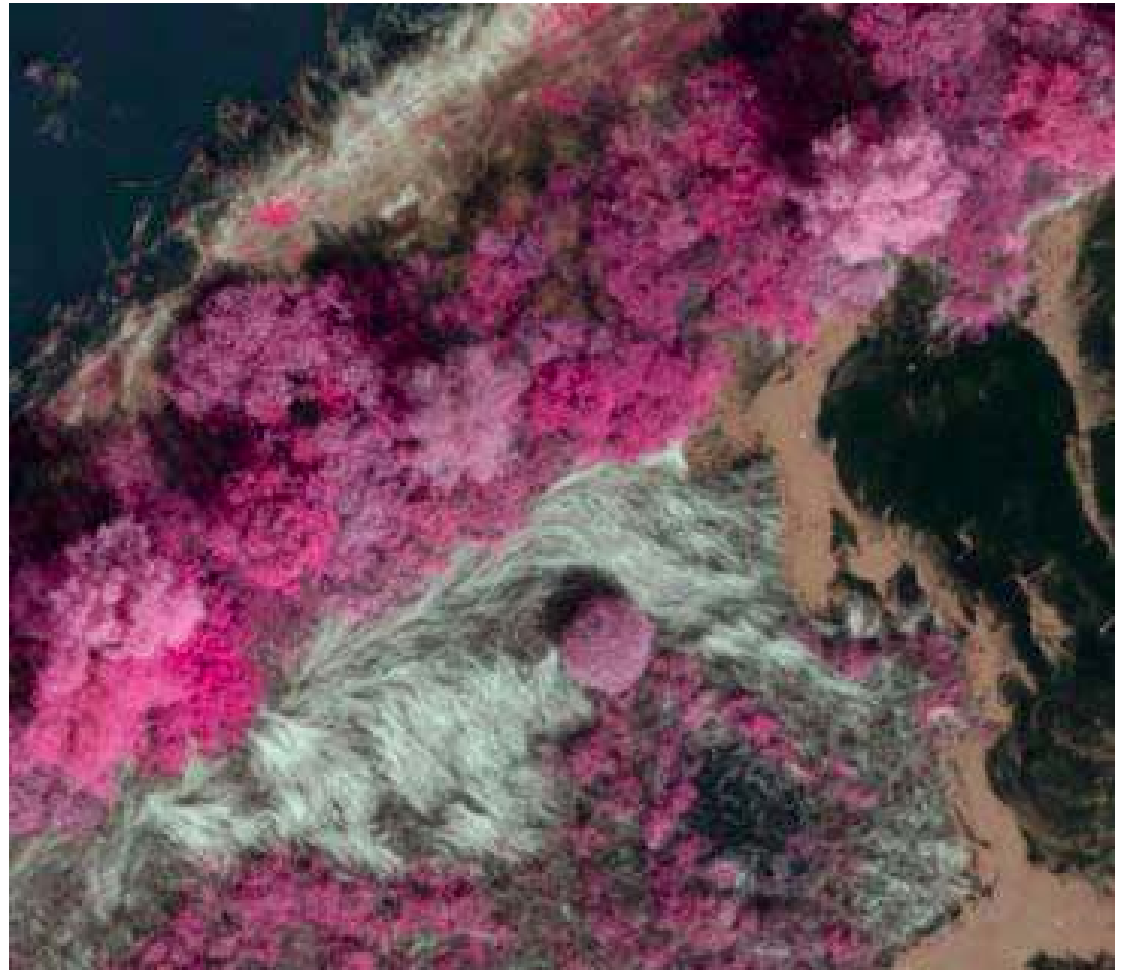
- when it has to be right

Leica
Geosystems

Global Service & Support Locations.

Support Location ⬤

Service Center ⬤
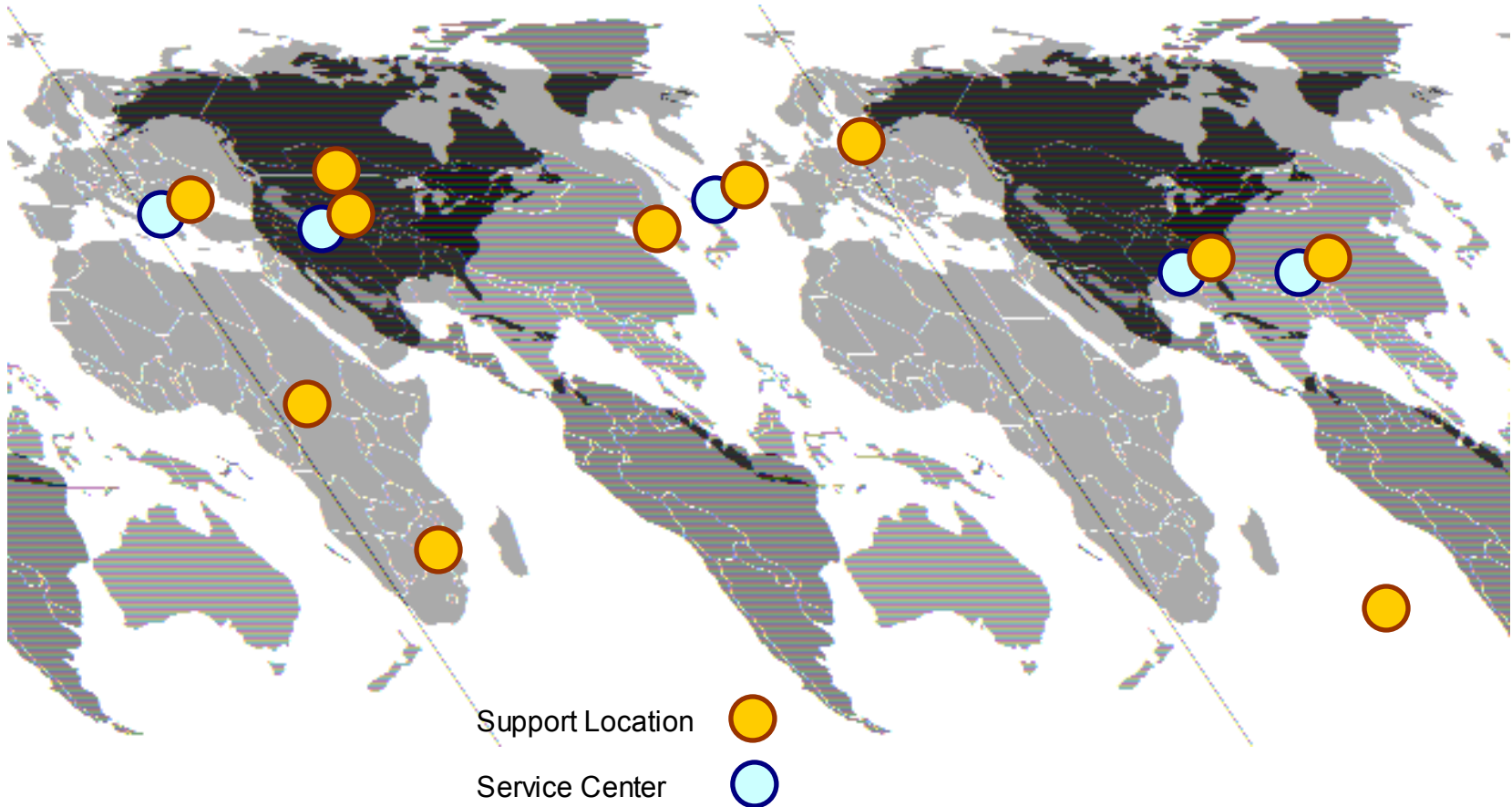
- when it has to be **right**   **Leica** *Geosystems*

Continued Technical Advances and how they benefit USDA programs

• Leica Geosystems has been a pioneer in the transition from aerial film cameras to the digital market. We had the first large format sensor on the market in 2001 and as you can see here, we have made continual technological advancements, which to date make it the most versatile, stable and complete mapping camera on the market. The ADS sensor has served the USDA NAIP program very well over the last several years and in fact their biggest NAIP contractor utilizes the technology.

▪ Leica Geosystems has designed and engineered the ADS with mapping in mind. We have ensured that our cameras are geometrically stable (put together right) and radio metrically the best (perfectly co-registered bands, spectral separation between bands, radiometric depth allowing to see in the shadows)
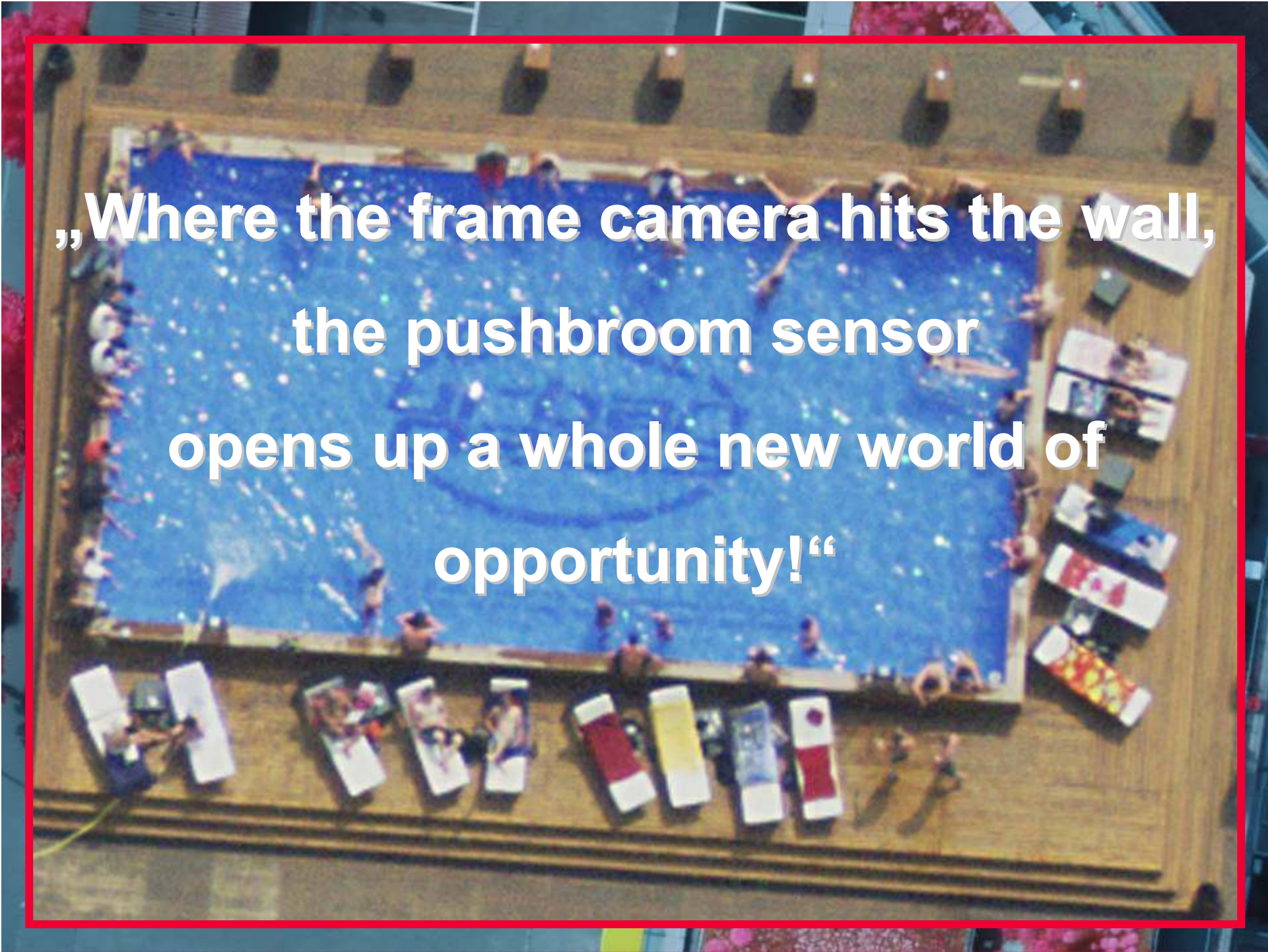
•Leica Geosystems currently offers the RCD105 camera system along with airborne LiDAR, which can serve natural resource programs of various size and GSD/point density requirements very effectively.

•Leica Geosystems has recently formed the Geospatial Solutions Division which brings together the Airborne Sensor Business Unit, the ERDAS Business Unit, and the Terrestrial Scanner Business Unit.

▪ ERDAS is launching the new Apollo product which will allow customers to easily and effectively serve and manage large geospatial datasets via the web.

▪ With XPro being the driving force behind ADS data processing now, project turn around time is much faster than before.

- when it has to be right

Leica
Geosystems

„Where the frame camera hits the wall, the pushbroom sensor opens up a whole new world of opportunity!"

Thank You!

Leica ADS
The Sensor.

ADS 80 SH82 Sensor Head

- when it has to be right Leica Geosystems

- when it has to be right Leica Geosystems

Appendix
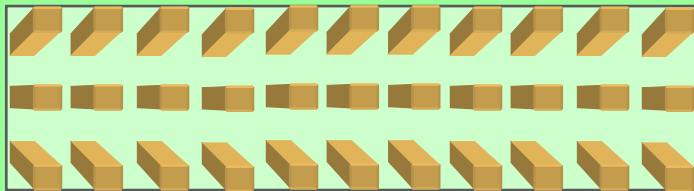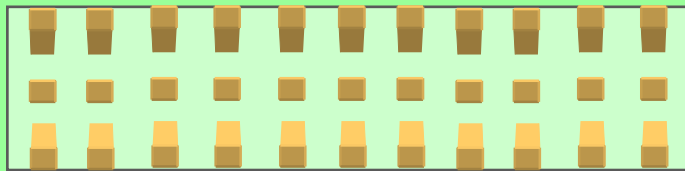
Effect of central perspective
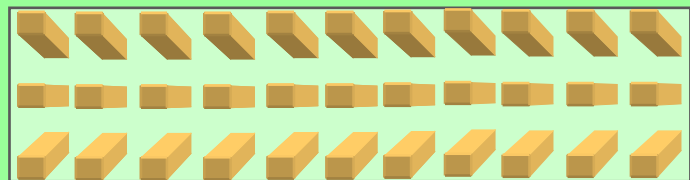
Airborne digital sensor ADS40/80

Forward view strip

Nadir view strip

Backward view strip

Analog aerial camera RC30

Photograph with central perspective
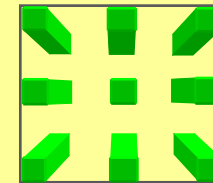
Flight line with overlapping photographs
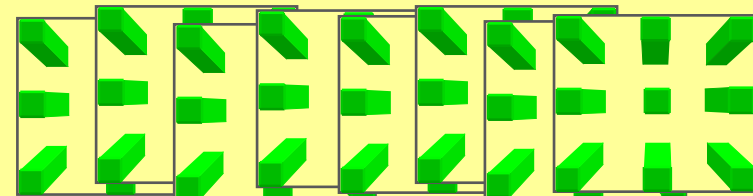
- when it has to be right

Leica Geosystems

Stereo-viewing comfort: Constant Stereo Angle

Left eye

Right eye

Forward pixel carpet with constant viewing angle

Nadir pixel carpet with constant viewing angle

Polarized glasses
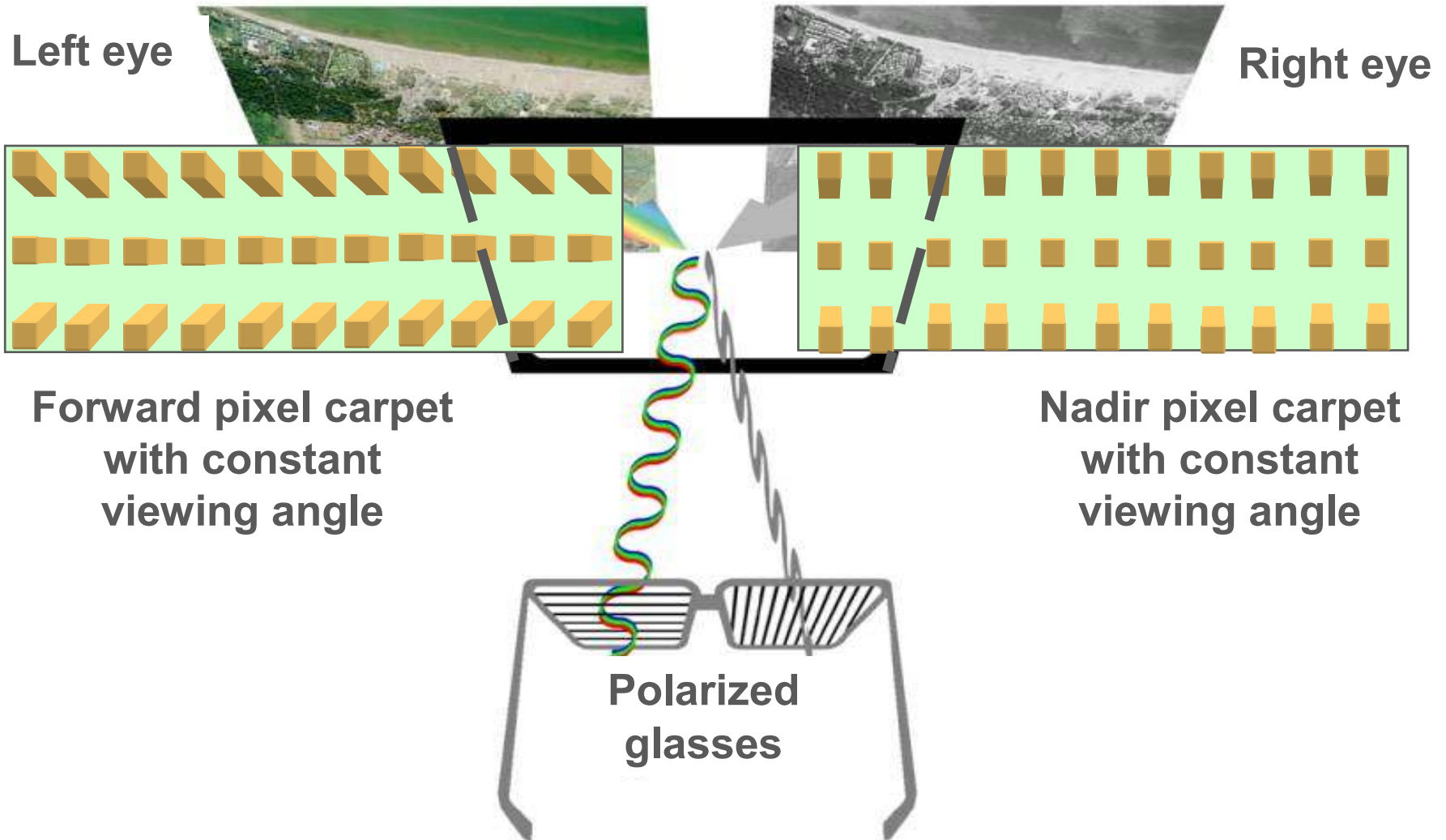
- when it has to be right

Leica
Geosystems

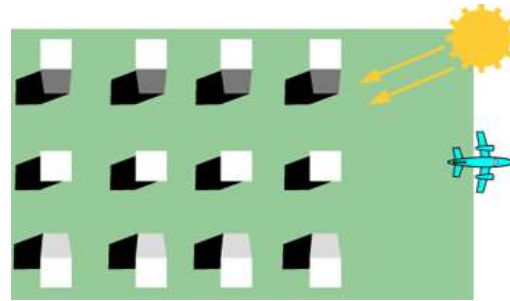# Parallel Line Perspective best for elimination of BRDF *

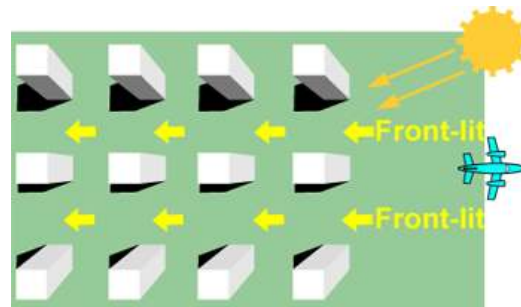**view from ADS40**   **Surfaces along track**   **Surfaces across track**

Forward
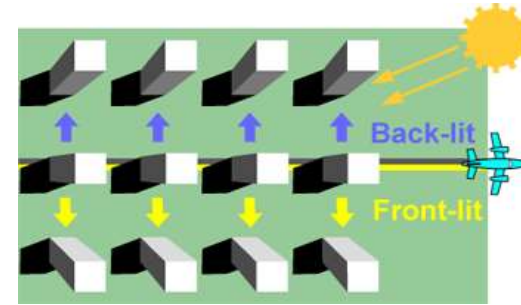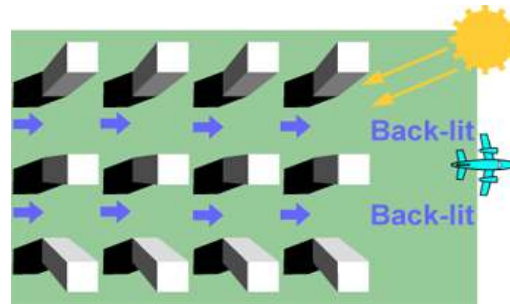
Nadir
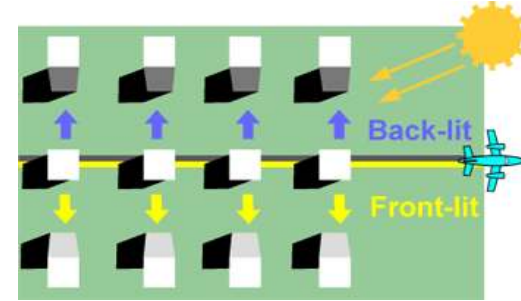
Backward
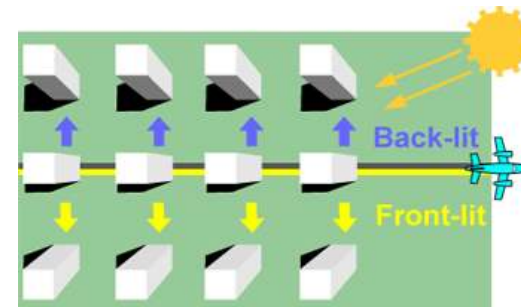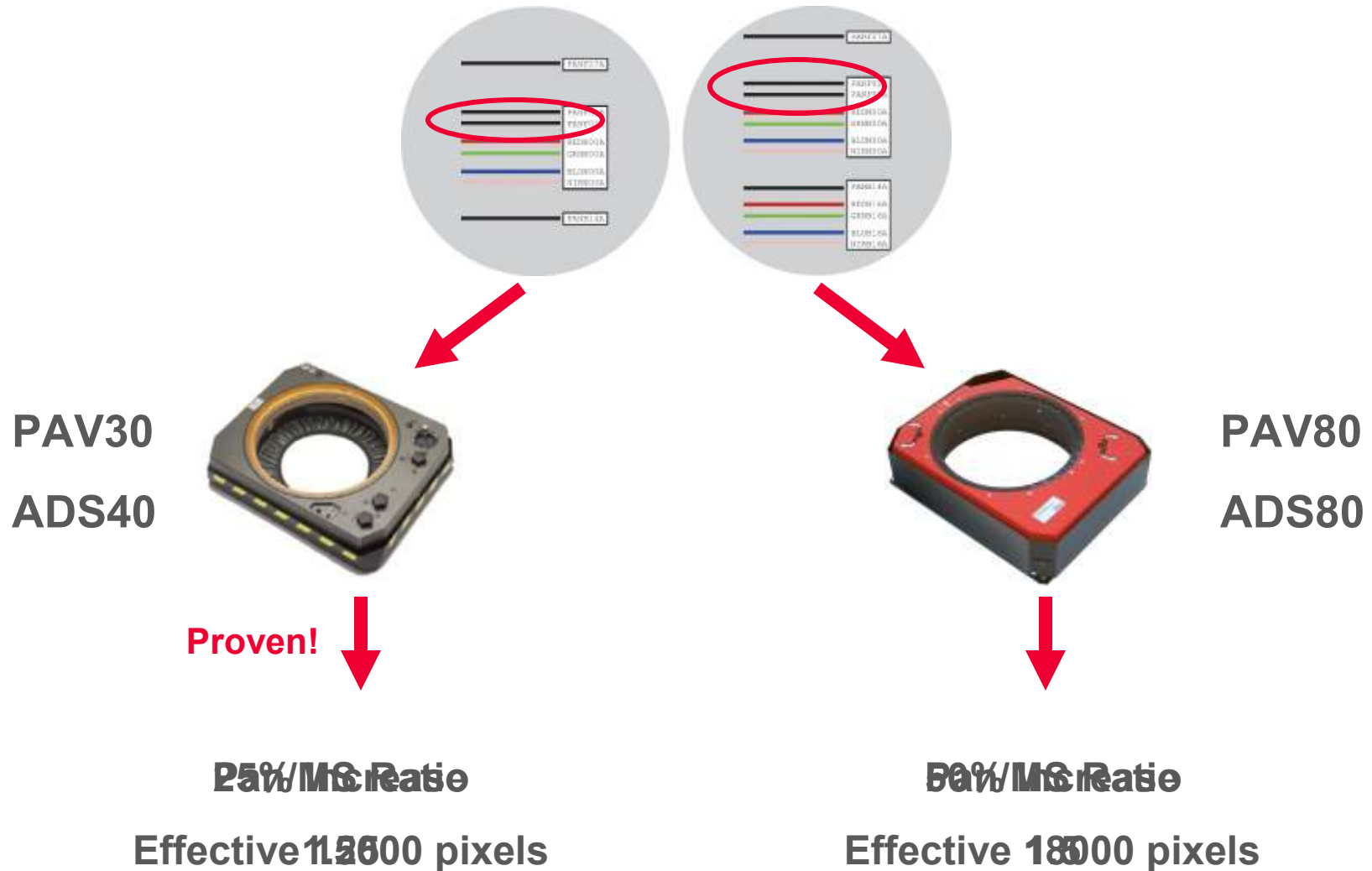
* BRDF = Bi-directional Reflectance Distribution Function

- when it has to be **right**

Leica Geosystems

Increased Efficiency through Staggered Line
24000 Pixels in Nadir

PAV30

ADS40

PAV80

ADS80

Proven!

Pan/MS Ratio 25% Increase

Effective 11600 pixels

Pan/MS Ratio 50% Increase

Effective 18000 pixels

- when it has to be **right**

Leica
Geosystems

Leica ADS80 – Lighter Sensors
Control Unit CU80 and MM80

- Highly reliable flash disk technology
- 364 GB / 768 GB capacity per MM80 pair
- Exchangeable In-flight
- Weight 2.5 kg

= total weight installed 190-195kg

Finally, after 14 years.............

..............Leica PAV80

Stabilization range in roll $- 7° \text{ to } ° + 7°$

Stabilization range in pitch $- 8° \text{ to } ° + 6°$

Stabilization range in drift $- 30° \text{ to } ° 30°$

Leica PAV80 - Lighter Sensors
Key Benefits

- **Accommodates sensors with a total weight from 5 kg up to 100 kg**

- **No need for a mass compensator.**

= total weight installed ~~150-100~~ kg

Post processing time – Leica XPro workflow

			Total time		User
			WS with 6 server cluster		action time
Flight	1,200 km², 15cm GSD 12 lines, each 80 km, 3 Pan and 8 MS Approximately 7 hr flight at 130 knots				
Download	400 GB ADS data format			4 h	0.5 h
Geo-referencing	Trajectory calculation geo-referencing of L0 images			0.5 h 0.1 h	0.5 h 0.1 h
Aerial triangulation	Automatic Point Measurement Bundle Adjustment			0.1 h 0.3 h	0.1 h 0.3 h
Ortho photo	RGB or FCIR 1,200 km²			1.7 h	0.1 h
				6.7 h	1.6 h

Feature extraction — Due to image strips slightly faster than in traditional workflow
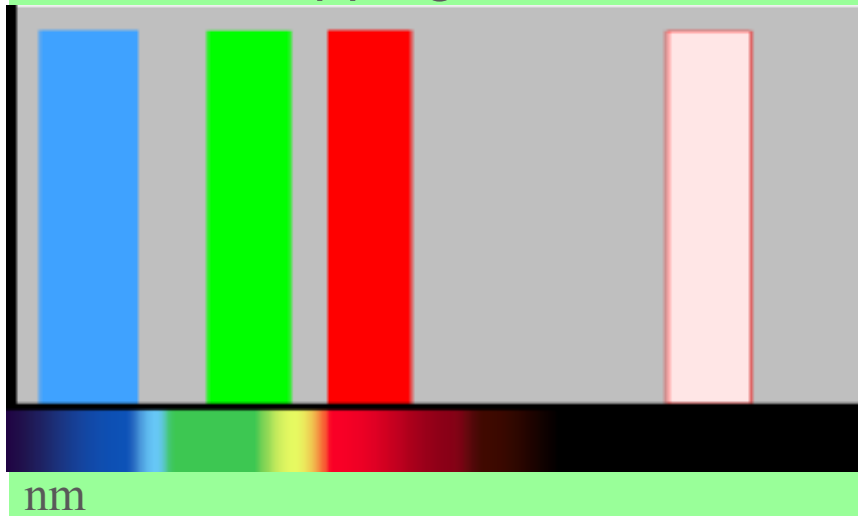
Fly-through — Similar to traditional workflow

- when it has to be right

Leica Geosystems

ADS80
Maintaining filter transmission characteristics

**Interference filters
Used in ADS40**

**Absorption filters
Used in CCD array cameras**

Non-overlapping narrow bands
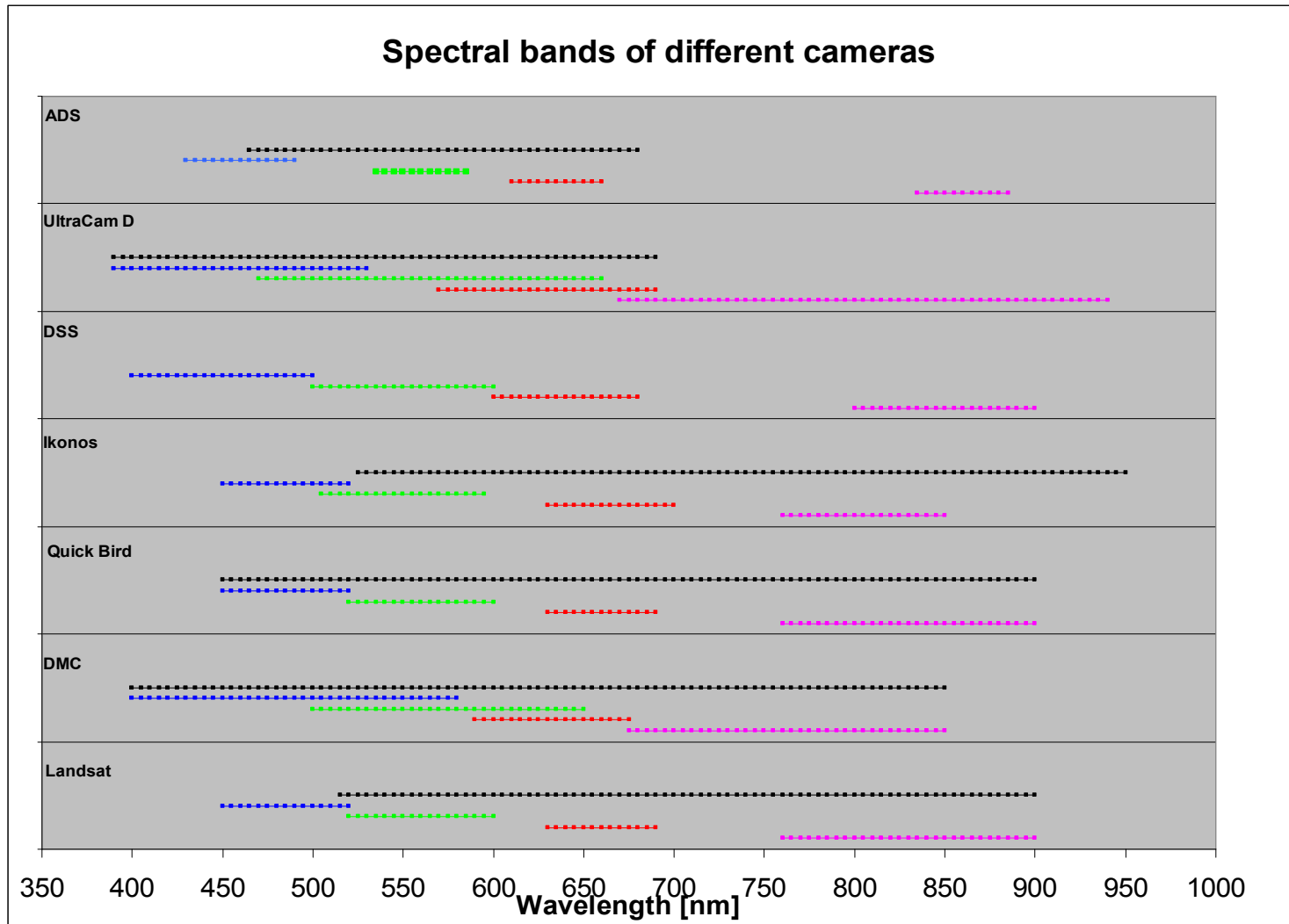
Overlapping bands

nm

nm
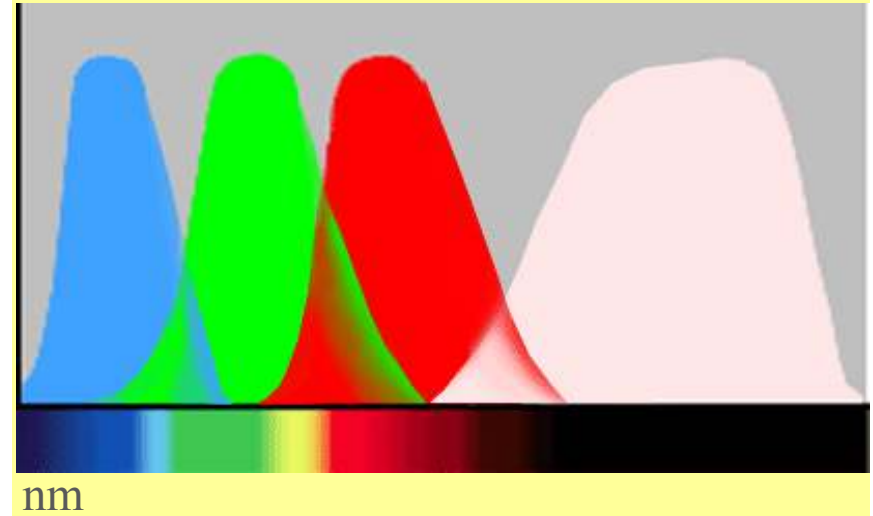
Interference filters are best for remote sensing applications where response in non-overlapping narrow bands is required

- when it has to be right

Leica
Geosystems

ADS80
Separate bands for Remote Sensing

Spectral bands of different cameras