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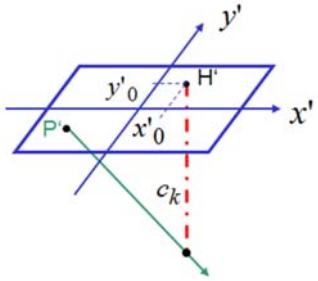
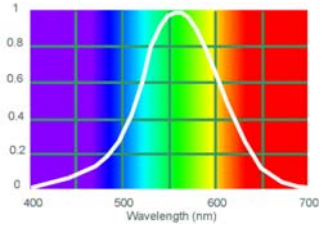
Geometry perfect – Radiometry unknown ?

Photogrammetric Week 2011
Stuttgart



Michael Cramer
Institut für Photogrammetrie (ifp)
Universität Stuttgart



michael.cramer@ifp.uni-stuttgart.de

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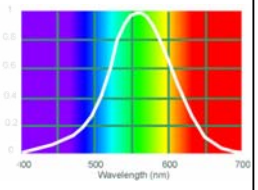
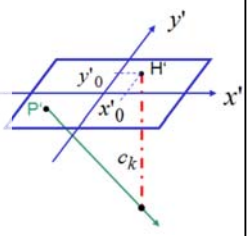
Remote Sensing vs. Photogrammetry ?
Terminology

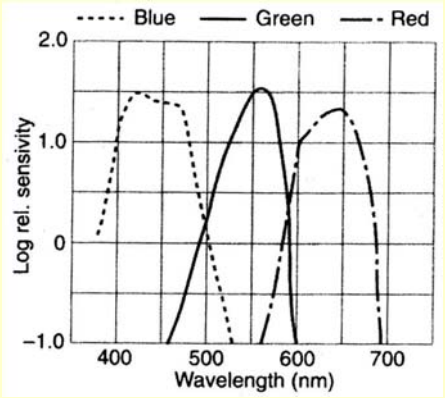
German Standard DIN 18716-3
"**Remote sensing** embraces **all methods of acquiring information** about the Earth's surface by means of measurement and interpretation of electromagnetic radiation either reflected from or emitted by it."



German Standard DIN 18716-1
"**Photogrammetry** deals with information on objects and processes, with **special focus on the shape, size and position of objects** in space. Preferable photographic imagery serves as information source. The images are taken by photogrammetric acquisition and processed in photogrammetric analysis."



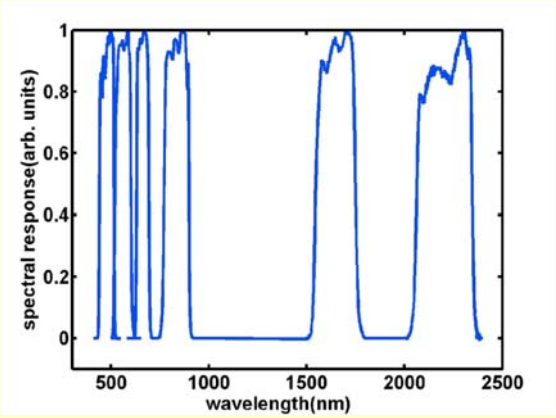
Remote Sensing vs. Photogrammetry ?
Spectral bands



Color negative film
Aviphot CN 200

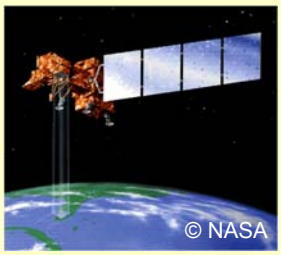
RMK-Top

Photogrammetry



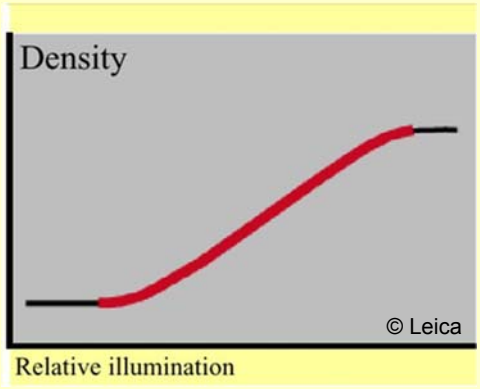
Landsat7 ETM+

Landsat7



Remote Sensing

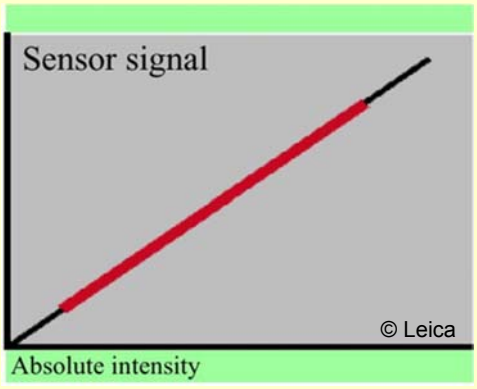
Remote Sensing vs. Photogrammetry ?
Characteristic curve



Film based imaging

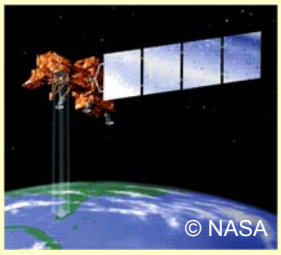
RMK-Top

Photogrammetry



Digital imaging

Landsat7



Remote Sensing

Remote Sensing vs. Photogrammetry ?

Digital airborne cameras

Part 1 - Introduction

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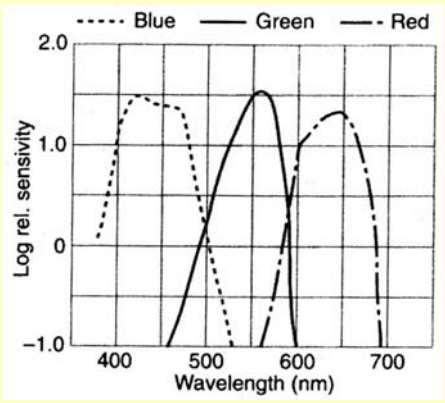
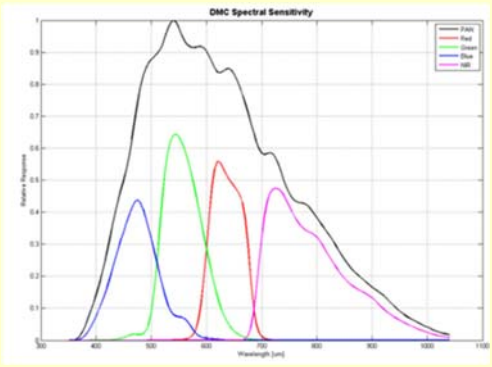


Color negative film
Aviphot CN 200

RMK-Top

Photogrammetry



DMC

Remote Sensing ?

Remote Sensing vs. Photogrammetry ?

Digital airborne cameras

Part 1 - Introduction

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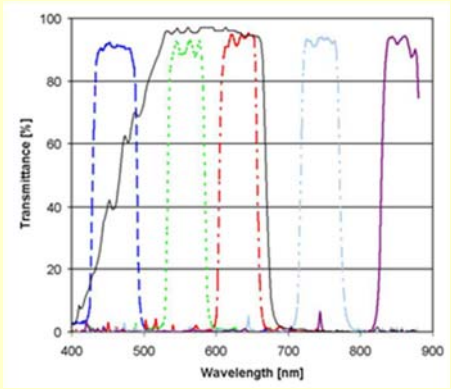
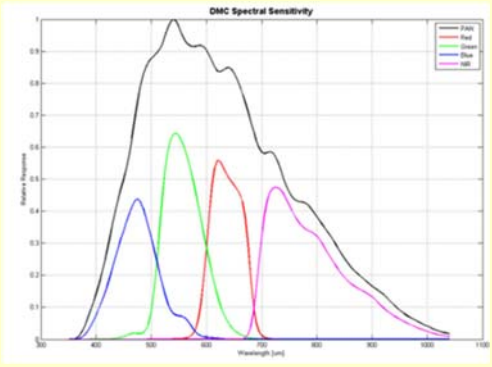


ADS

Photogrammetry ?

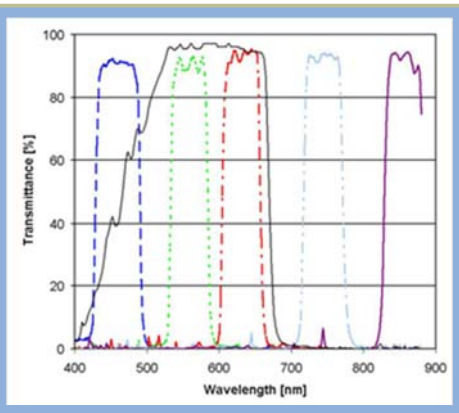


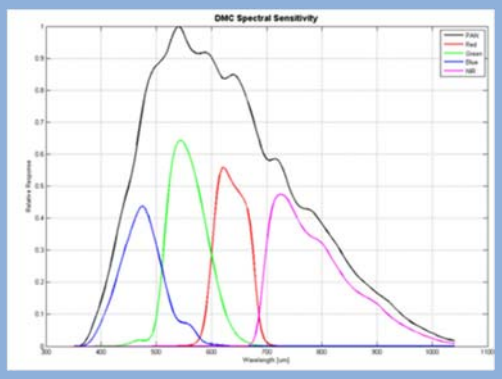
DMC

Remote Sensing ?

Remote Sensing vs. Photogrammetry

Digital airborne cameras





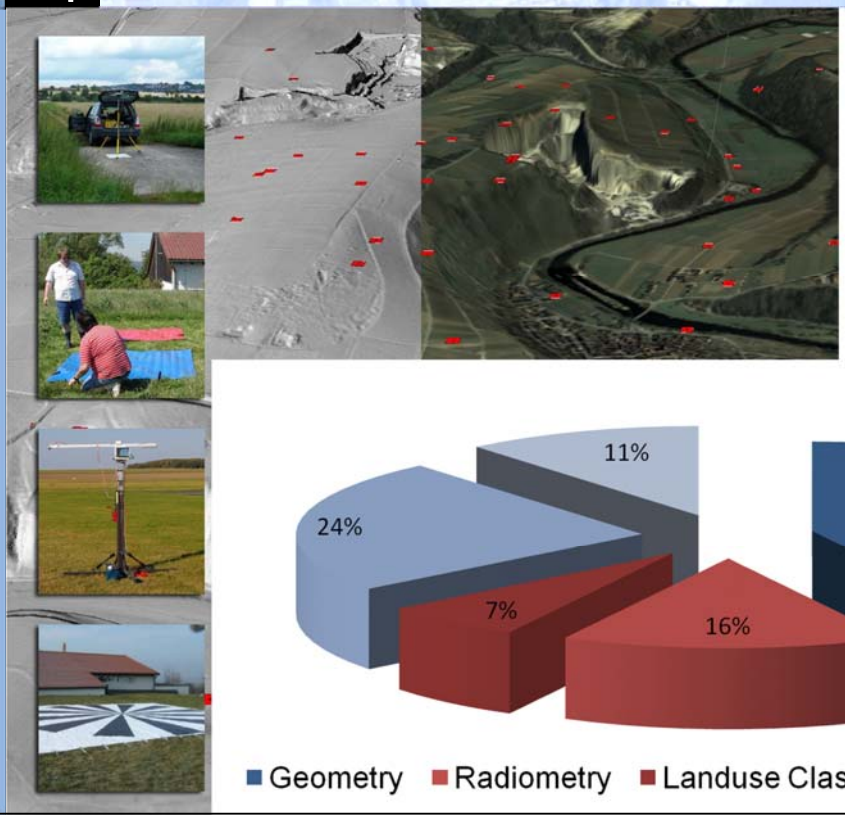
ADS

DMC

Photogrammetry
&
Remote Sensing

Snapshot I

DGPF test: Digital Airborne Camera Evaluation



~ 45 active participants

Snapshot II
Lectures on radiometry during Phowo

- Phowo 2009 (**2 of 33, 6%**)
  - **Ryan, Pagnutti**: Enhanced Absolute and Relative Radiometric Calibration for Digital Aerial Cameras
  - (Dörstel: RMK D – A True Metric Medium-Format Digital Aerial Camera System)
- Phowo 2007 (**2 of 33, 6%**)
  - **Honkavaara, Markelin**: Radiometric Performance of Digital Image Data Collection - A Comparison
  - (Fricker: Raising the Bar for Multi-Band High-Resolution Airborne Imagery)
- Phowo 2005 (**1 of 36, 3%**)
  - (Leberl, Gruber: ULTRACAM-D: Understanding some Noteworthy Capabilities)
- Phowo 2003 (**2 of 32, 6%**)
  - (Reulke: Film-based and Digital Sensors – Augmentation or Change in Paradigm?)
  - (Bjick, Shevlin: Monitor Calibration)
- Phowo 2001 (**0 of 36, 0%**)
  - -

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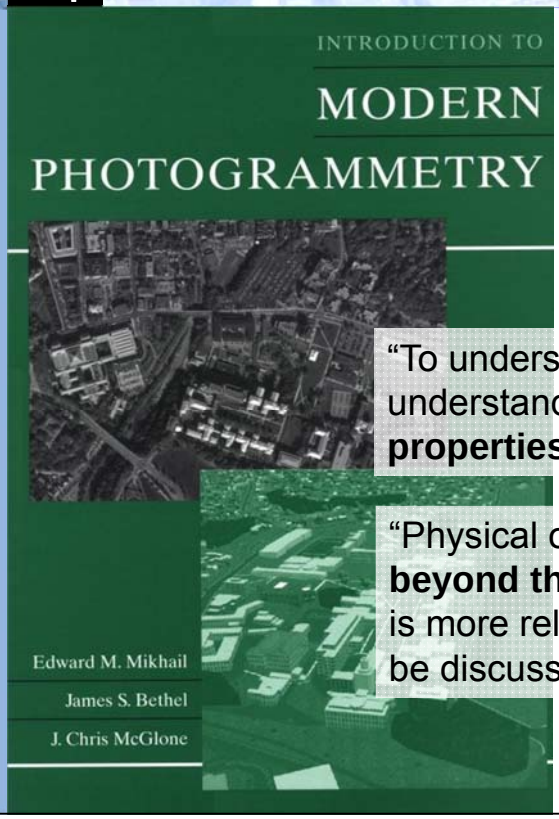
Snapshot III
Photogrammetric text book

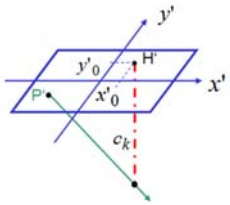


"To understand photogrammetric sensors we must understand the **geometric and radiometric properties** of electromagnetic radiation."

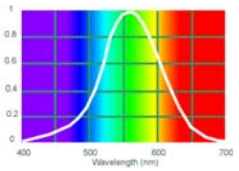
"Physical optics deals with the **radiometry** and **is beyond the scope of this book**. Geometric optics is more relevant to photogrammetric issues and will be discussed."

published in 2001

Outline



Geometry perfect –
Radiometry unknown ?



Part 1: Introduction

Part 2: The manufacturer's perspective

Part 3: The user's perspective

Part 4: The standard's perspective

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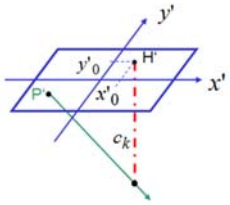
Outline



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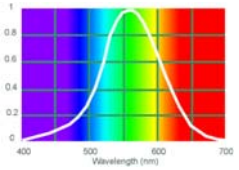

Part 1: Introduction

Part 2: The manufacturer's perspective

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Part 4: The standard's perspective

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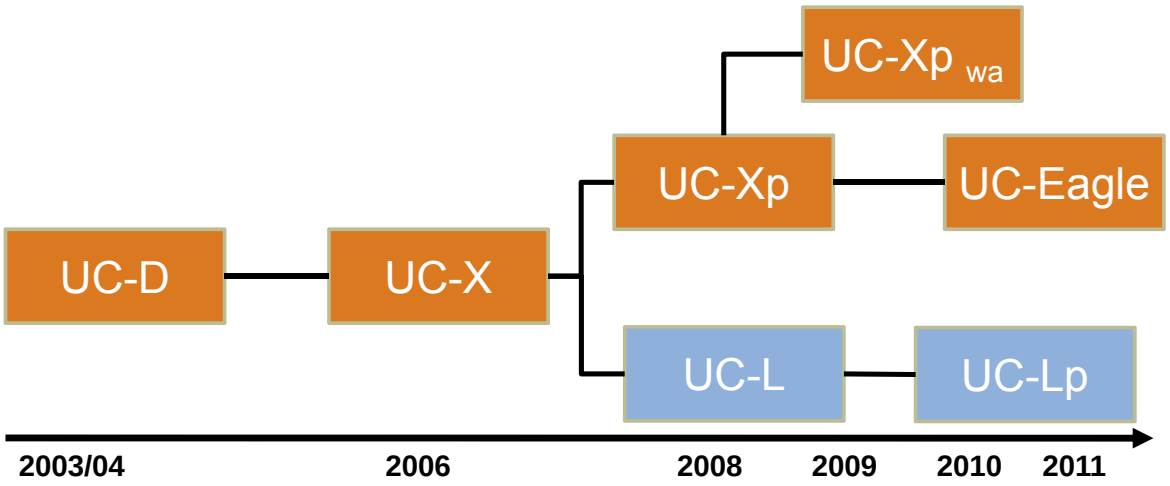
Digital airborne imaging sensor systems
Evolution of systems

The Vexcel Imaging UltraCam family



following

Part 2 – Manufacturer's View
Universität Stuttgart

Digital airborne imaging sensor systems
Evolution of systems

The Vexcel Imaging UltraCam family

Camera product generation	Year of market introduction	Image extension		Pixelsize @ sensor [µm]
		PAN (virtual, from 9 CCDs in 4 heads)	MS (original resolution)	
UltraCam-D	2003	**11500 x 7500pix** 103.500x67.500 mm²	**3680 x 2400pix** 33.120x21.600 mm²	**9.0**
UltraCam-X	2006	**14430 x 9420pix** 103.896x67.824 mm²	**4810 x 3140pix** 34.623x22.608 mm²	**7.2**
UltraCam-Xp	2008	**17310 x 11310pix** 103.860x67.860 mm²	**5770 x 3770pix** 34.620 x 22.620 mm²	**6.0**
UltraCam-Eagle	2011	**20010 x 13080pix** 104.052x68.016 mm²	**6670 x 4360pix** 34.684 x 22.672 mm²	**5.2**

Digital airborne imaging sensor systems
Design of spectral bands

Part 2 – Manufacturer's View

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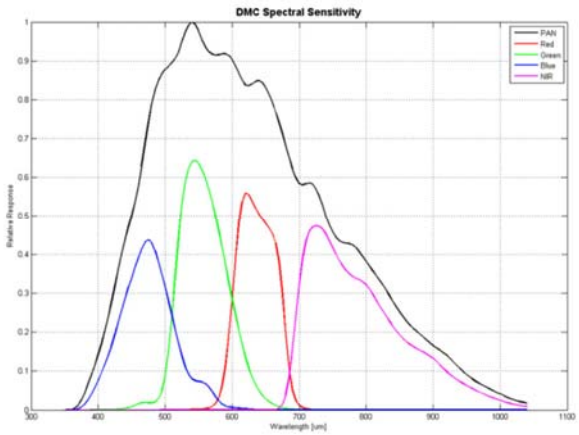

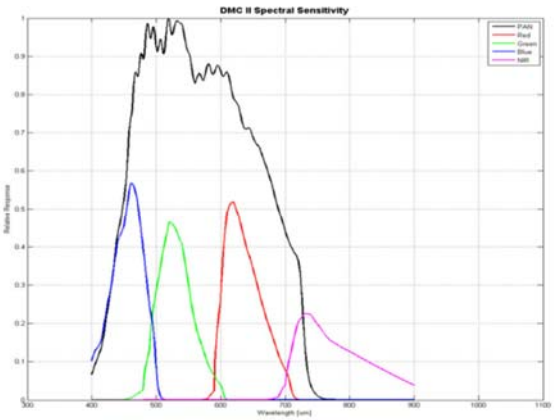

DMC

DMC II 250

Digital airborne imaging sensor systems
Current status

Part 2 – Manufacturer's View

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Sensor	concept	Image size		# camera heads
		PAN	MS (original resolution)	
UltraCam-Eagle Vexcel Imaging	**Frame** **Pan multi-head** **Virtual images**	20010 x 13080pix @ 5.2µm	6670 x 4360pix @ 5.2µm, PAN:MS 1:3	4 (pan) 4 (MS)
DMC II 250 Intergraph/ZI	**Frame** **Pan single head** **No virtual images**	16768 x 14016pix @ 5.6µm	6800 x 6096pix @ 7.2µm PAN:MS 1:2.4	1 (pan) 4 (MS)
ADS80 Leica Geosystems	**Line** **Single head** **Line images**	12000pix @ 6.5µm (no staggering applied)	12000pix @ 6.5µm, PAN:MS 1:1	1

Ultracam-Eagle

DMC II 250

ADS 80

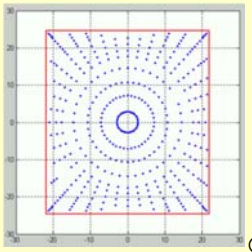
Geometric calibration
DMC calibration

"Past"

Zeiss Oberkochen goniometer set-up

Today

Zeiss Jena collimator set-up



Part 2 – Manufacturer's View
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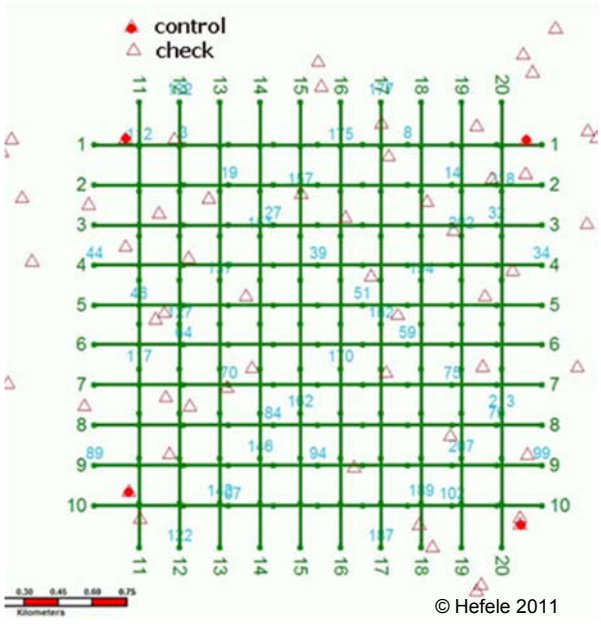
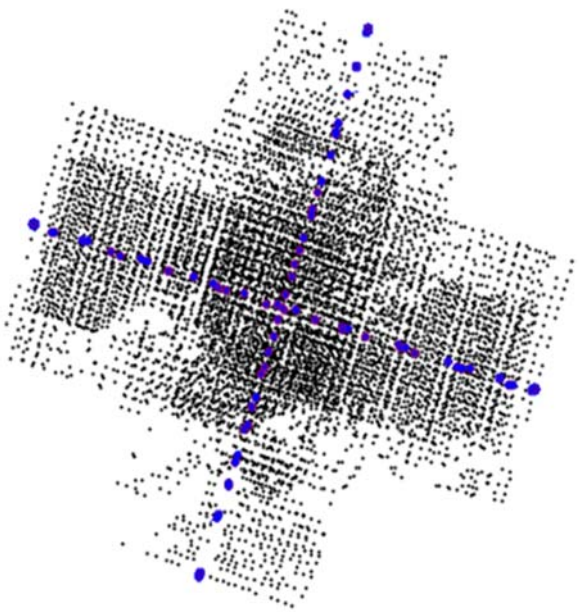
Geometric calibration
In-situ calibration



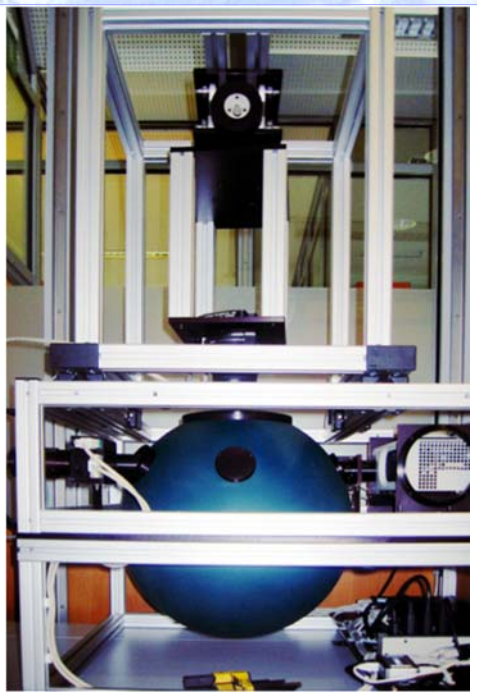
DMC in-situ calibration layout



ADS in-situ calibration layout

Radiometric sensor calibration
Laboratory equipment

Integrating sphere (90cm diameter) at Leica Geosystems



Integrating sphere (51cm diameter) at Intergraph/ZI

Part 2 – Manufacturer's View
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Radiometric processing
Leica XPro

- „standardized“ airborne images using radiometric calibration factors which allows further remote sensing data products
- Full radiometric processing chain presented by Beisl / Telaar / Schönermark (ISPRS 2008, Beijing)
- Calibrated DN are related to at sensor radiances
- Ground radiance / ground reflectance imagery considering atmospheric corrections and BRDF effects

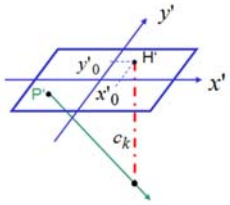
The manufacturer's view

- Geometric calibration is shifted from lab to in-situ calibration fields (paradigm shift?)
- refinement of calibration models is still done

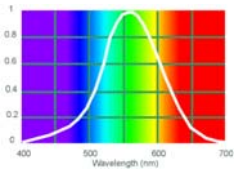
- Radiometric calibration almost completely from well defined lab calibration
- Increasing effort spend in radiometry, namely radiometric processing of image data

From system's manufacturers point of view, calibration of sensors is under full control and obviously most of the user's feel sufficient with the calibration as provided by the manufacturers

Outline



Geometry perfect –
Radiometry unknown ?



Geometric performance

- Individual testing of systems
- Scientific / national / international performance tests, i.e.
  - EuroSDR Digital Camera Calibration Network (completed 2009)
  - DGPF Camera Evaluation test (completed 2010)
- **But** discussion on geometric accuracy hardly seems to be an issue any more!
  - i.e. ISPRS Workshop on High Resolution Earth Imaging 2011 only 1 paper on geometric performance analysis
  - Standard use of bundle adjustment with self-calibration models
- „Geometry perfect" ◄► „Geometry sufficient enough"◄► „Geometry accepted"

Part 3 – User's View
Universität Stuttgart

Independent evaluation of radiometric performance

Radiometric aspects of digital photogrammetric images (EuroSDR project)

Finnish Geodetic Institute (FGI) and Institut Cartogràfic de Catalunya (ICC)

- investigate and advance the utilization of the image radiometry
  - **Improve knowledge** on radiometric aspects
  - **Review methods** of for radiometric image processing
  - Compare solutions through processing of **empirical data sets**
  - Analyse benefit of radiometrically corrected data in different **applications**

Final report pending, but very comprehensive online journal paper:

***Honkavaara, E. et al., 2009**. Digital airborne photogrammetry – A new tool for quantitative remote sensing? – Remote Sensing, Vol. 1, 577-605*

Independent evaluation of radiometric performance

Radiometric aspects of digital photogrammetric images (EuroSDR project)

Conclusions from questionnaire (as of 2009)

- Improvements are requested for the entire process: sensors, calibration, data collection, data post-processing, data utilization.
- Fundamental problems:
  - Insufficient information of radiometric processing chain
  - Inadequate radiometric processing lines
  - Missing standards (methods, calibration, targets, terminology)
- The basic radiometric end products requested by image users are true color images and reflectance images.
- Expected benefit of more accurate radiometric processing:
  - more automatic and efficient imagery post-processing
  - better visual image quality
  - more accurate, automatic interpretation, remote sensing use

Part 3 – User's View
Universität Stuttgart

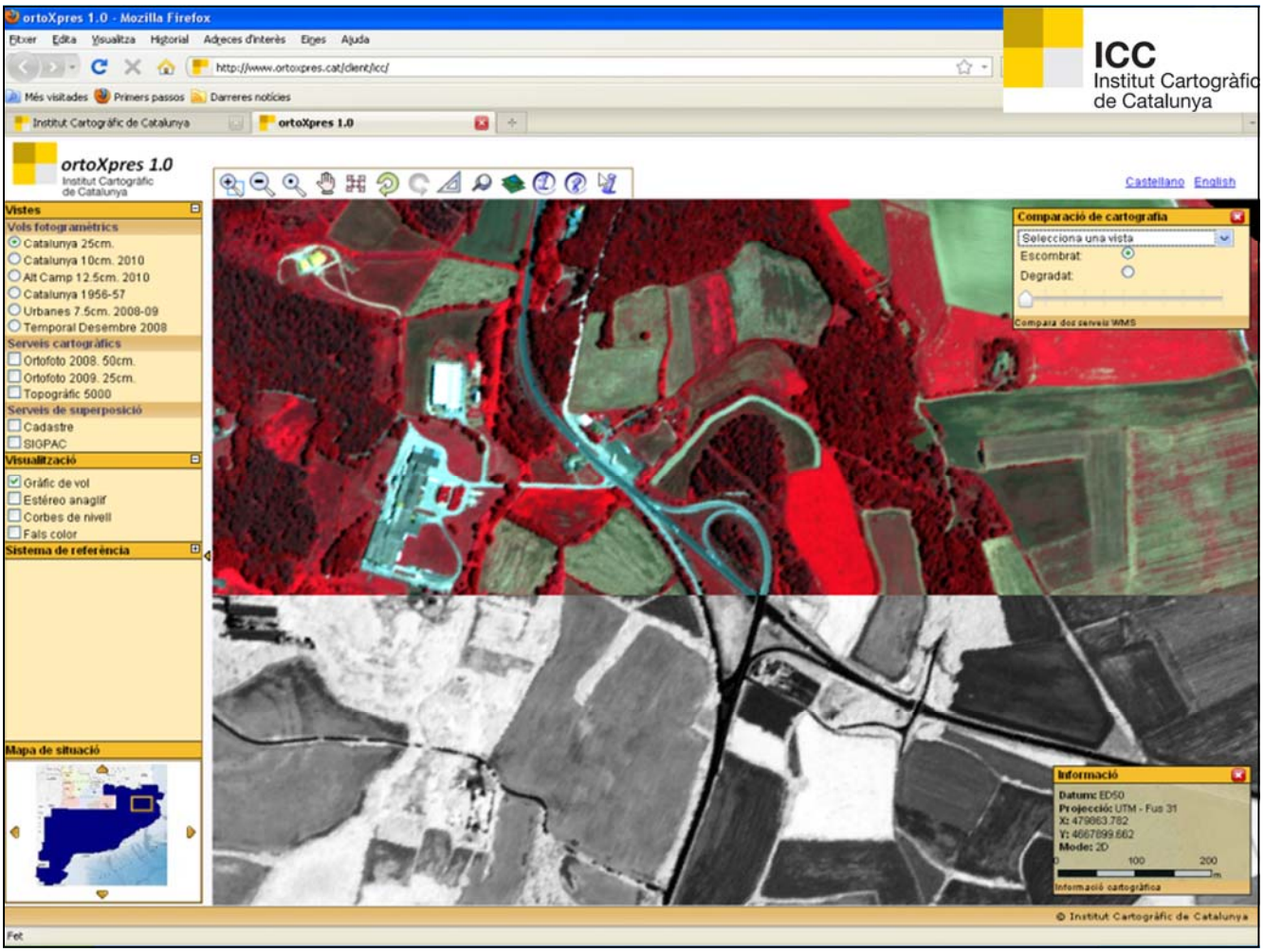
Radiometric block equalization
IGN – Pepita software

before *after*

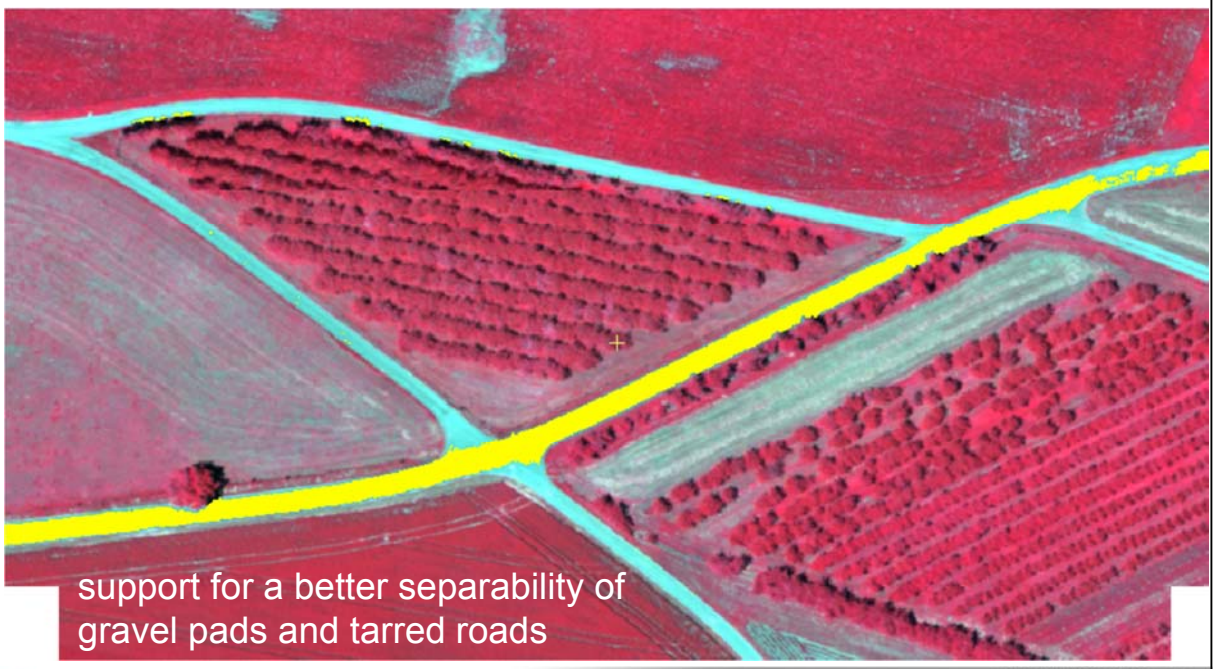
- Equalizing a block of digital images, relative radiometric calibration.
- Based on a parametric, semi-empirical radiometric model based on BRDF, haze differences, solar elevation, sensor settings (exposure) and others
- parameters are computed through a global least-squares minimisation process, using radiometric tie-points in overlapping areas between the images ("**radiometric aerial triangulation**").

Applications from production

- ICC (Barcelona, Catalonia): country wide NDVI data sets from DMC images
  - > 32000 km² of Catalonia in 2011 for the Agriculture Department of Regional Government to verify agricultural policy
  - vegetation layer will be freely disseminated according to ICC data policy through Webmap Service
- swisstopo (Switzerland): (close to automated) production of
  - Roof types
  - road surface types
  - Forest extraction (under investigation)



Further applications from production
Example: swisstopo – road surface types



support for a better separability of gravel pads and tarred roads

Part 3 – User's View

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Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesverwaltung admin.ch
Eidg. Departement für Verteidigung, Bevölkerungsschutz und Sport
Bundesamt für Landestopografie swisstopo

Further applications from production
Example: swisstopo – forest extraction

Part 3 – User's View

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Schweizerische Eidgenossenschaft
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Confederaziun svizra

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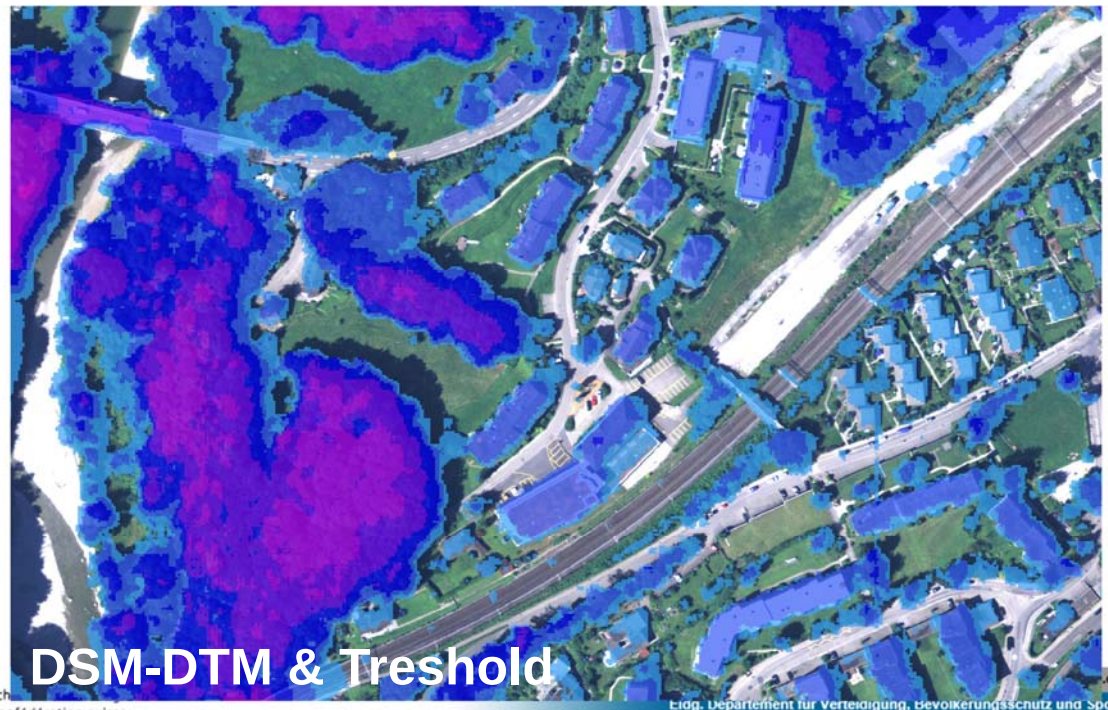
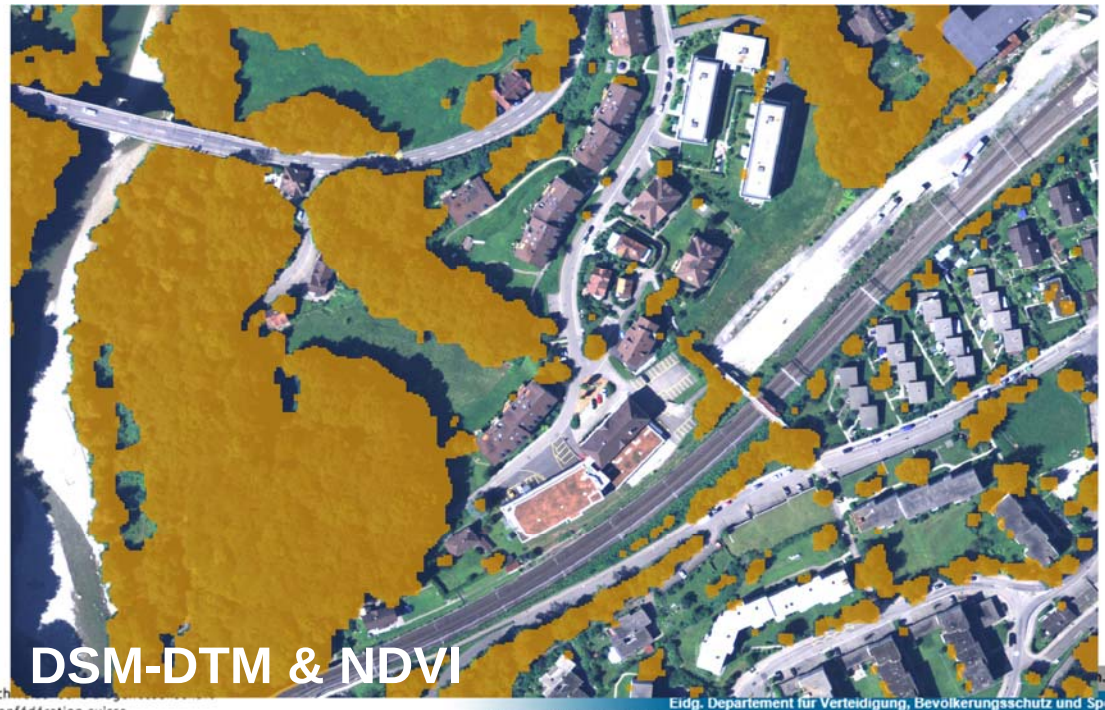
Further applications from production
Example: swisstopo – forest extraction



Further applications from production
Example: swisstopo – forest extraction



Part 3 – User's View
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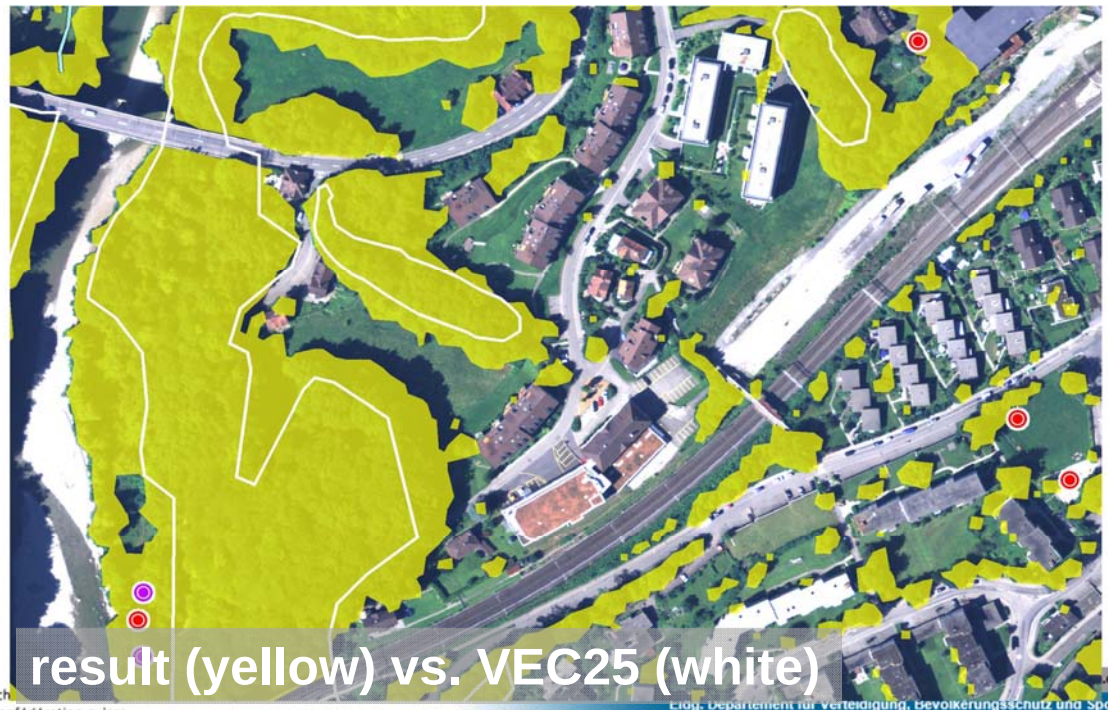
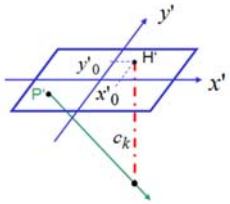
Confederazione Svizzera
Confederaziun svizra
Eidg. Departement für Verteidigung, Bevölkerungsschutz und Sport
Bundesamt für Landestopografie swisstopo

Further applications from production
Example: swisstopo – forest extraction



Outline



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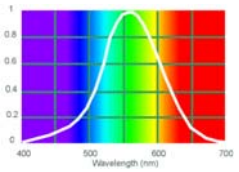

Part 1:	Introduction
Part 2:	The manufacturer's perspective
Part 3:	The user's perspective
Part 4:	The standard's perspective

Standardization

- Standards are essential, also for later certification processes
- German standards DIN 18740 series „Photogrammetric Products“
  - Part 4: Requirements of digital aerial cameras and digital aerial photographs
  - Part 5: Classification of optical remote sensing data
  - Part 6: Requirements of digital height models (under preparation)
  - Part 7: Requirements on pan-sharpening (under preparation)
- International standardization
  - ISO TS 19159 “Geographic information – Calibration and validation of remote sensing imagery sensors – Part 1: Optical sensors”

Need for standards ?
Example: Sensor calibration in US

- Former: **USGS calibration as mandatory quality proof**
- USGS quality assurance plan (► Phowo 2007)
  - Data procurement: Contract requirements & validation processes
  - Date acquisition: Manufacturer / Sensor type certification & Data producer certification

  now modified to „Independent Sensor Evaluation“
- **private companies** offering calibration service: service covers „in-situ camera calibration for analog and digital mapping cameras and independent accuracy validation of map products produced by airborne cameras.” (press release Navmatica, May 2011)

Need for standards ?
Example: Sensor calibration in US

Navmatica Launches Geometric Calibration and Validation Services for Aerial Mapping Cameras

POSTED BY NAVMATICA ON MAY 9, 2011 IN NEWS | 0 COMMENTS

RICHMOND HILL, ON – Navmatica announced today the launch of new services for geometric calibration and validation of airborne mapping cameras. Services include In-situ camera calibration for analog and digital mapping cameras and independent accuracy validation of map products produced by airborne cameras.

With the recent announcement by the USGS at the ASPRS 2011 Conference in Milwaukee that they no longer intend to provide camera calibration or digital aerial type certifications past the end of 2012, anyone wishing to continue using their analog film camera will require it to be calibrated In-situ using a well-controlled photogrammetric process. Navmatica offers this service for customers so that they do not have to invest in developing an in-house process, and to ensure they obtain consistent, reliable results. Additionally Navmatica offers independent validation services on final map product accuracy that can be used to help "self-certify" a new digital sensor type.

"Navmatica has a long history in providing consulting services for photogrammetric mapping", said Dr. Mohamed Mostafa, Chief Technical Officer for Navmatica Corporation. "By tapping into this vast experience we are able to offer geometric calibration and industry that are of the absolute highest quality standard. confidence they need to deliver geometrically accurate da

In-situ airborne camera calibration services include:

Press release May 9, 2011

http://www.navmatica.com/navmatica-launches-geometric-calibration-and-validation-services-for-aerial-mapping-cameras/

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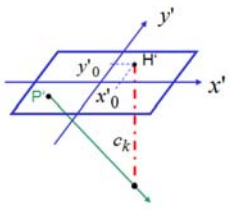
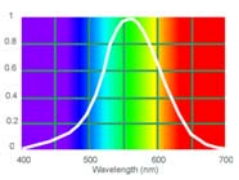
Summary

- Illustration of general status in digital airborne imaging with special emphasis on geometry and radiometry
- Geometry was first – radiometry strongly evolving, but not yet highlighted by system providers?
- Still some deficiencies / lacks of information (user's side / manufacturers side) which ask for further improvement, i.e. full understanding of camera radiometry but also on geometry



Geometry perfect –

Radiometry unknown ?



Yes? / No? / Perhaps?

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