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Calibration and validation of digital airborne cameras

The EuroSDR network on Digital Camera Calibration

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Calibration & Validation of digital airborne cameras

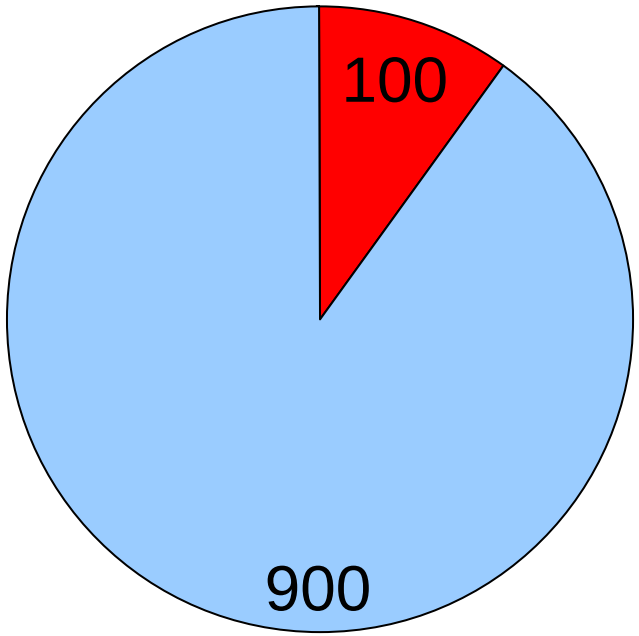
Status of airborne imaging

*"Are **large-format digital** cameras already playing a **substantial role** in photogrammetric world?"*

Status of airborne imaging

- analogue and digital in parallel
- heterogeneous world

Airborne sensor market
Today



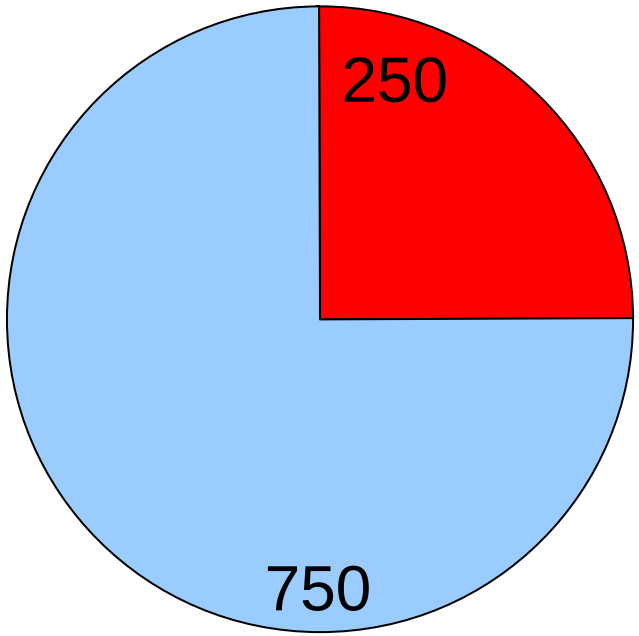
Number of systems

TODAY

- ~ 100 large-format digital sensors (ADS, DMC, UC) and in operational use
- ~ 900 analogue airborne cameras
- ~ 10% digital

Airborne sensor market

5 years projection



TODAY

- ~ 100 large-format digital sensors (ADS, DMC, UC) and in operational use
- ~ 900 analogue airborne cameras
- ~ 10% digital

Fore-cast (after 5 years)

- +30 new system sales per year for digital sensors (ADS, DMC, UC)
- -30 analogue systems disappearing per year
- ~ 25% digital
- number of projects?

Status of airborne imaging

- digital airborne mapping is not only of interest but in **operation** and **production** already
- **products** from digital sensors available
  - orthoimage mosaics, terrain models, stereo-plotting
- NMAs already decided to **exclusively** use digital image data acquisition in future (Lantmäteriet Sweden)!

- new cameras and concepts appearing continuously
- **no** commonly accepted definitions
- **no** official and certified procedures for quality assurance and quality control (calibration and validation)

- **Digital airborne imaging and mapping is in its wild-west phase right now** (USGS, 2006)

International activities

- Empirical sensor testing and final product validation
  - by system **vendor**
  - by **science** or **indepent organizations** (USGS, FGI) or EuroSDR
    - Recommendation/development of commonly accepted procedure(s) for camera systems calibration/validation
    - based on experimental testing within users network
  - by potential **customer**

- Standardization
  - International: ISO standard 19130 Sensor and data models for imagery and gridded data (under progress)
  - Germany: DIN standard 18740 Photogrammetric Products – Part 4: Requirements for digital airborne sensors and images (under progress)

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Calibration & Validation of digital airborne cameras

The EuroSDR network “Digital Camera Calibration”

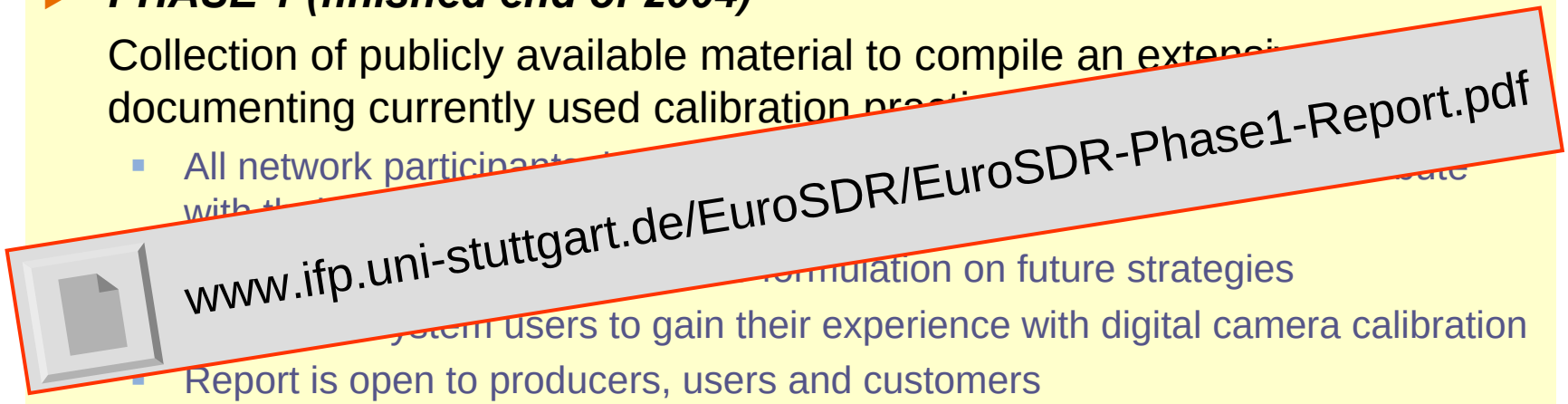
“Transfer of knowledge and experience”

Objectives

- ***PHASE 1 (finished end of 2004)***

  Collection of publicly available material to compile an extensi
  documenting currently used calibration practi

  - All network participant
  - formulation on future strategies
  - system users to gain their experience with digital camera calibration
  - Report is open to producers, users and customers



- ***PHASE 2 (under progress)***

  Recommendation/development of commonly accepted procedure(s) for camera systems calibration and experimental testing

  - Focus on some of the technical aspects in a sequential order, i.e. starting with geometrical aspects and verification followed by radiometry
  - Empirical testing should *not* lead to direct comparisons of cameras, but to individual calibration recommendations for each digital camera design

Network members

#	Group	Institutions	#
1	Camera manufacturers	ADS, DIMAC, DMC, DSS, UltracamD, Starimager, 3-DAS-1, DigiCAM	8
2	Software developers	BLUH, ORIMA, inpho, dgap	4
3	Other companies	Vito, ISTAR, Geosys, OMC, CSIRO, Itacyl	6
4	Science	ETH, OSU, Glasgow, Stuttgart (U and HfT), IdeG, Rostock, DLR, Berlin, Nottingham, Aas, Pavia, Anhalt, Leon	14
5	NMAs	ICC, USGS, OrdSurv, IGN, FGI, NLH, Swedish LandSurvey, Swisstopo, BEV, Inst. Cart. Valenciano	11
		Σ	43

Experimental Phase II data

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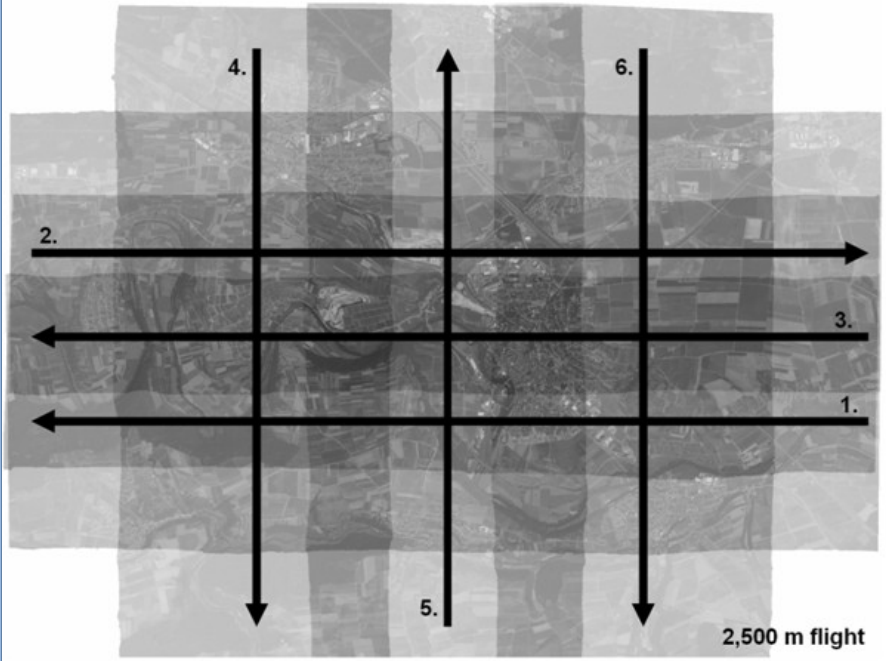
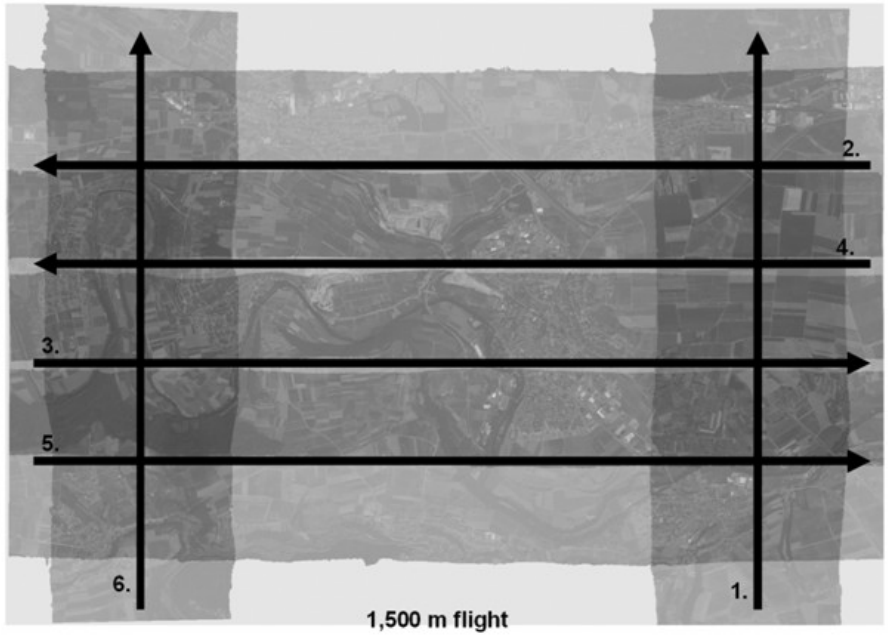
#	Altitude [m]	GSD [m]	# strips long/cross	% overlap long/cross	# Images	Additional data
ADS Vaihingen/Enz, *June 26*, 2004						
1	1500	0.18	4 / 2	100 / 44	36	GPS/INS
2	2500	0.26	3 / 3	100 / 70	36	GPS/INS
DMC Fredrikstad, *October 10*, 2003 *(demanding data set)*						
1	950	0.08	5	80 / 30	115	-
2	1800	0.15	3	80 / 30	34	-
UltracamD Fredrikstad, *September 16*, 2004 *(demanding data set)*						
1	1900	0.17	4 / 1	80 / 60	131	GPS
2	3800	0.34	2	80 / 60	28	GPS

Experimental Phase II data
ADS data Vaihingen/Enz

ADS Vaihingen/Enz, June 26, 2004



2500m block



1500m block

object points

12 control points

>200 check points

Experimental Phase II data
DMC data Fredrikstad

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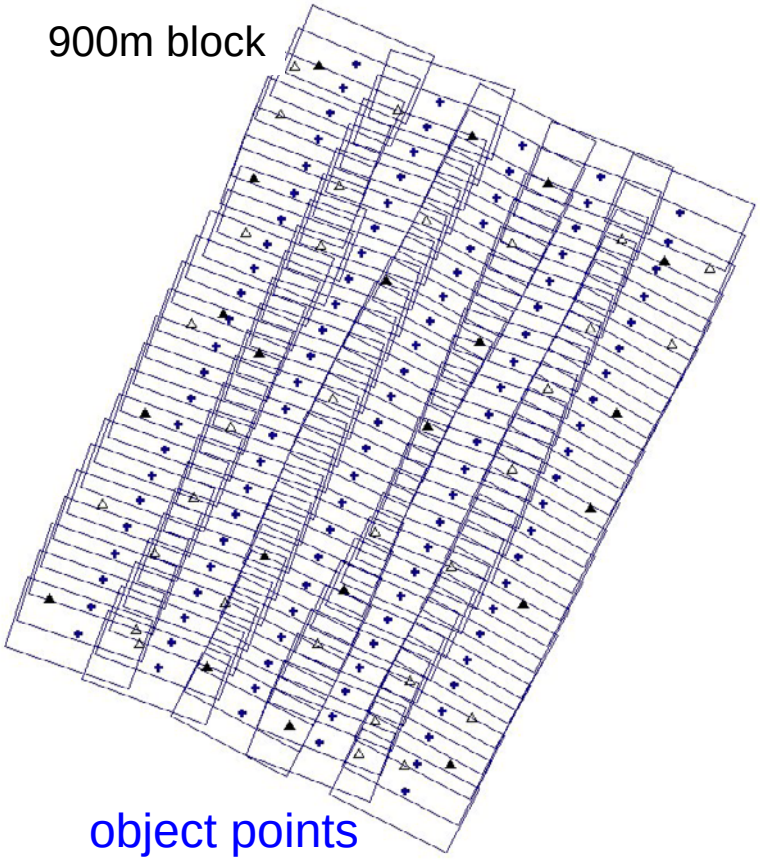
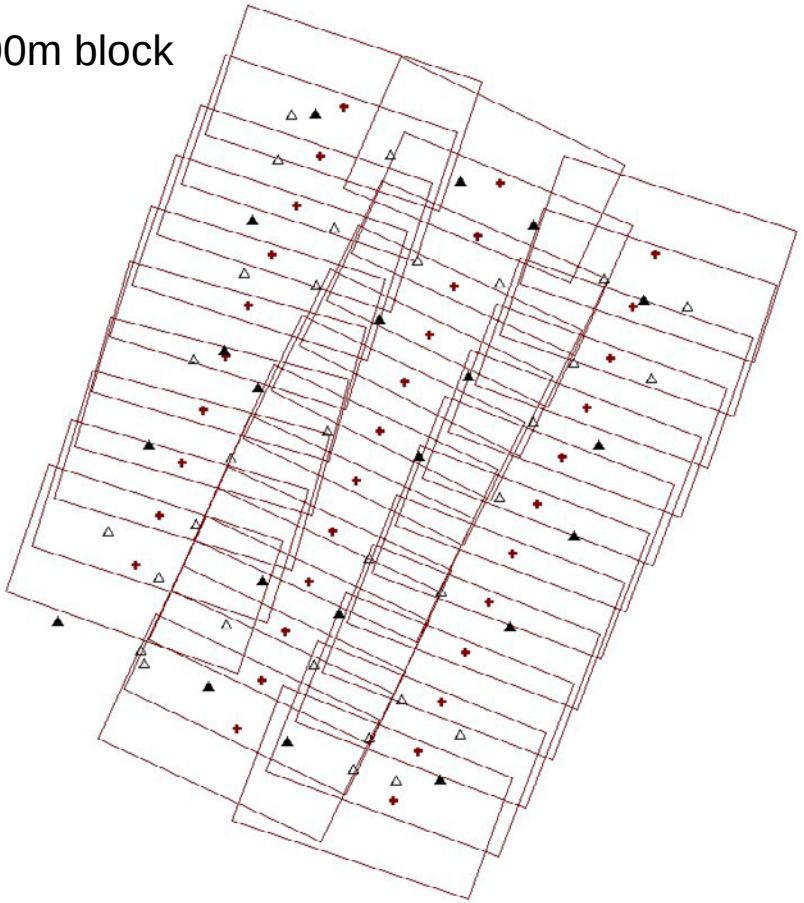
The EuroSDR Calibration network

DMC Fredrikstad, October 10, 2003

900m block



1800m block



object points

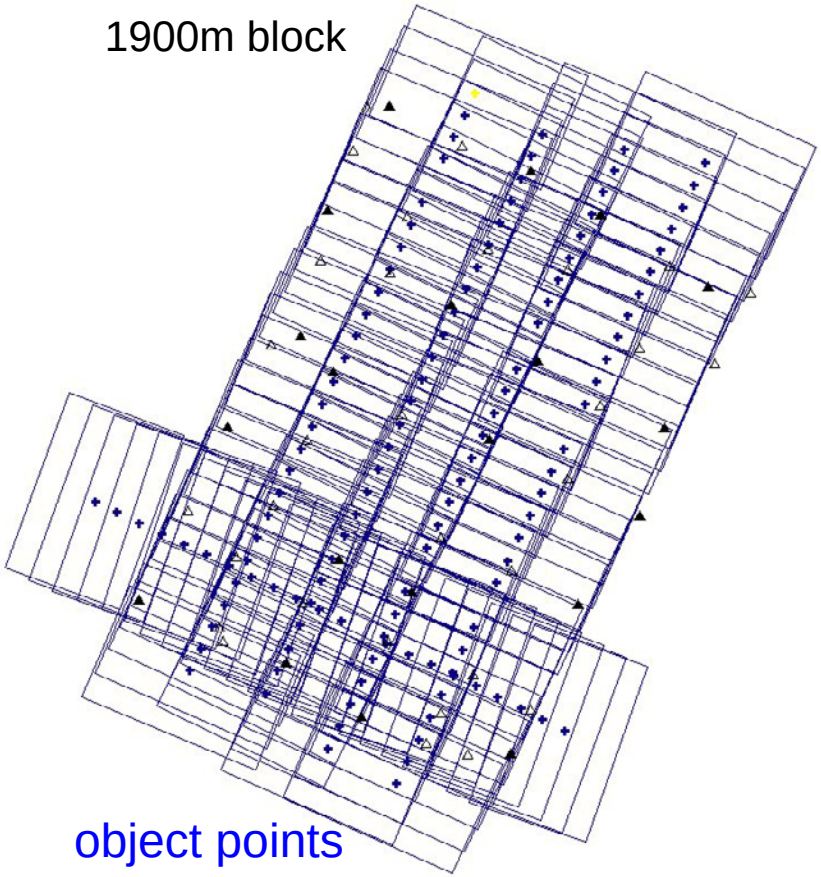
~ 20 control points

~ 25 check points

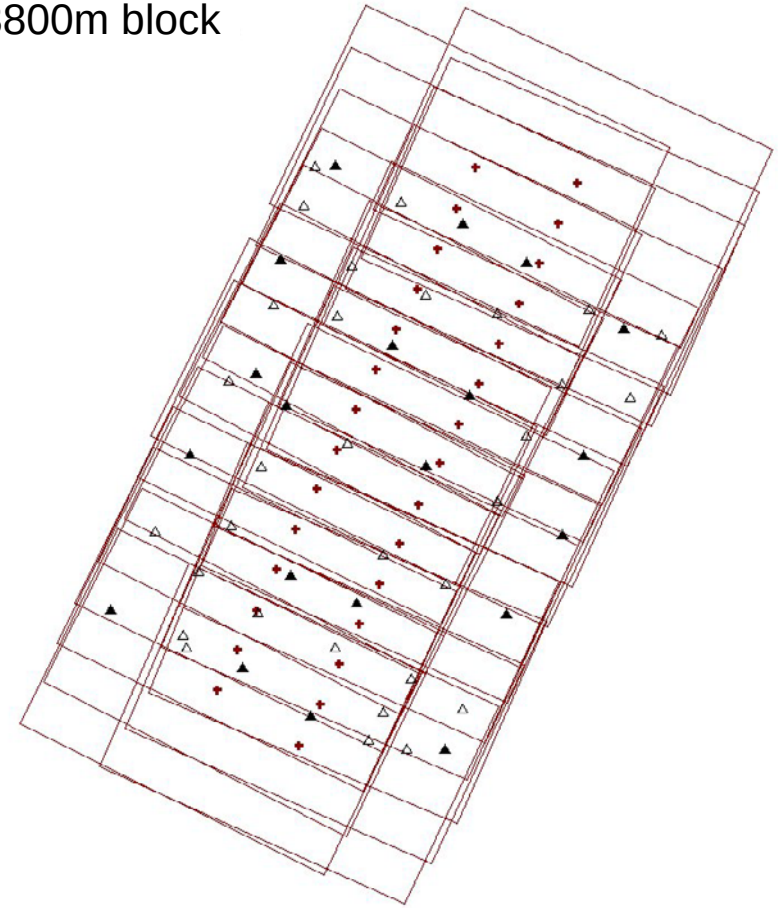
Experimental Phase II data
UCD data Fredrikstad

UltracamD Fredrikstad, September 16, 2004

1900m block



3800m block



object points

~ 20 control points

~ 25 check points

Experimental Phase II data

Image quality and point measurements

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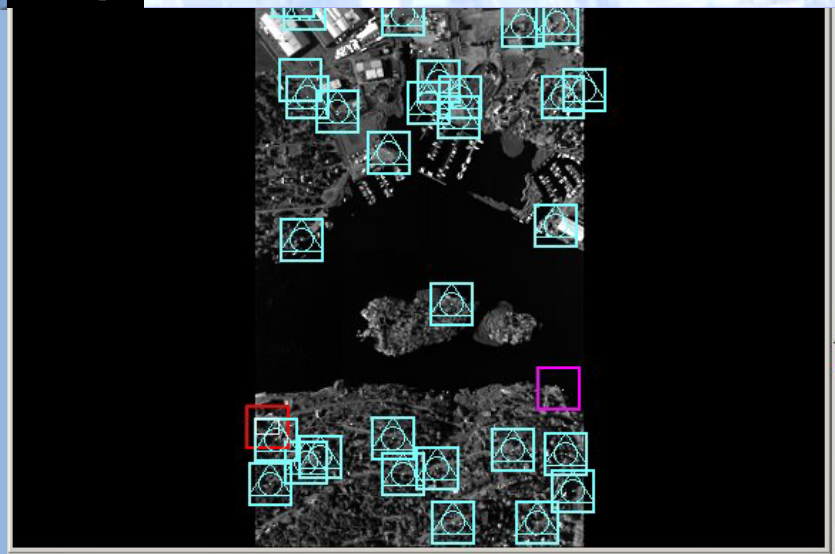
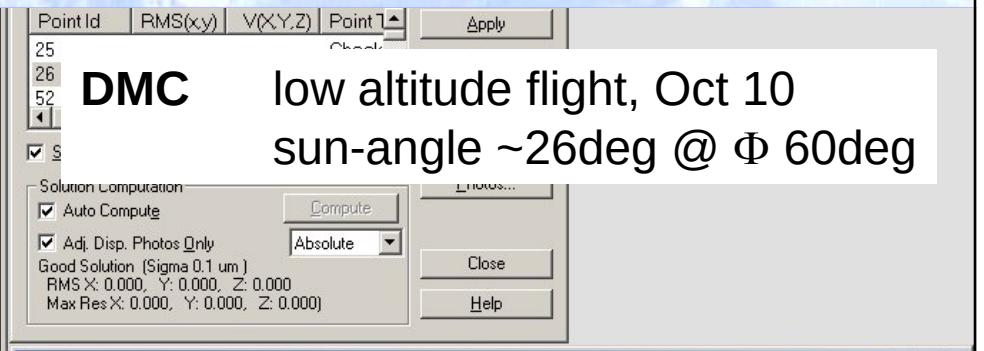
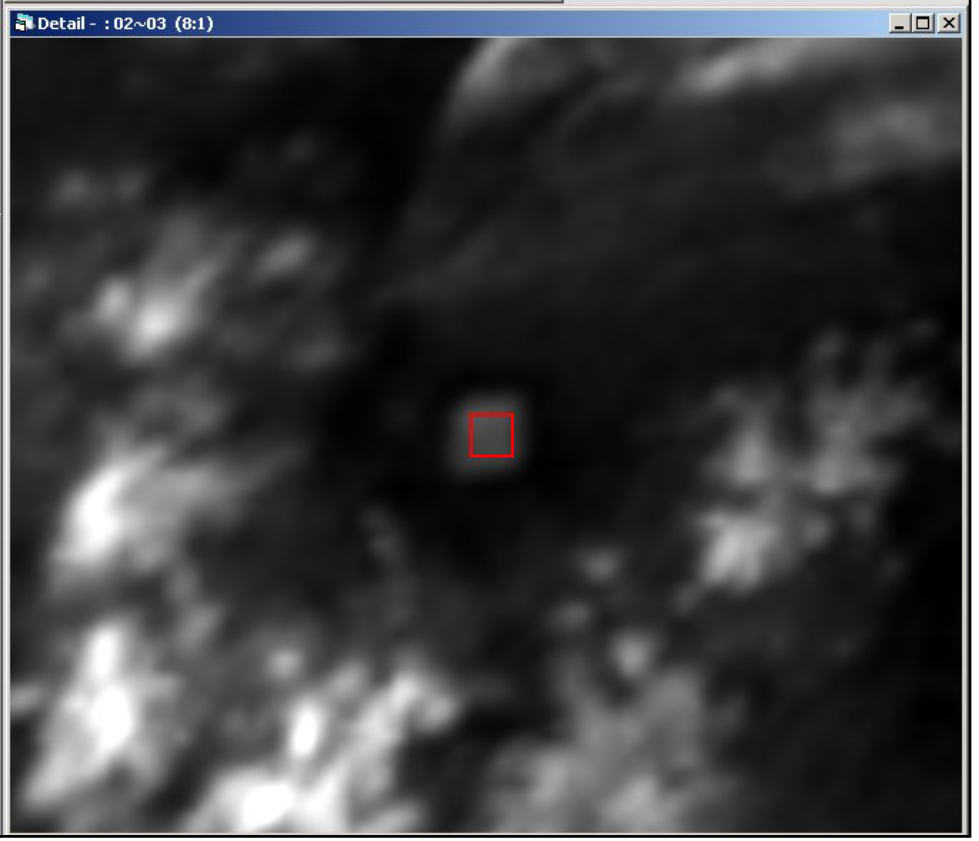




DMC low altitude flight, Oct 10
sun-angle ~26deg @ Φ 60deg



Phase II
Data request and distribution

- What data was **provided** to participants from pilot centre ?
  - Image data (PAN first) – only one data set in first round
  - sufficient GCP coordinates, **ChP only with approx. coordinates** to reduce measurement process
  - EO values (from GPS/inertial or approx. values from a priori adjustment)
  - GCP and ChP sketches

Phase II Data Set	# Requests
ADS	5
DMC	8
UltracamD	6

Phase II
Data processing and return

- What does pilot centre **expect** from participants ?
  - results from AT, including list of ChP coordinates, optimal result has to be classified
  - brief report on evaluation strategy, i.e.
    - different flying heights used separately or in combined approach
    - additional parameter sets, used models
  - general experiences / recommendations from this and other data sets obtained so far

Phase II Data Set	# Requests	# Returns
ADS	5	2
DMC	8	4
UltracamD	6	4

Status: June 30, 2006

Phase II

Preliminary results DMC Fredrikstad

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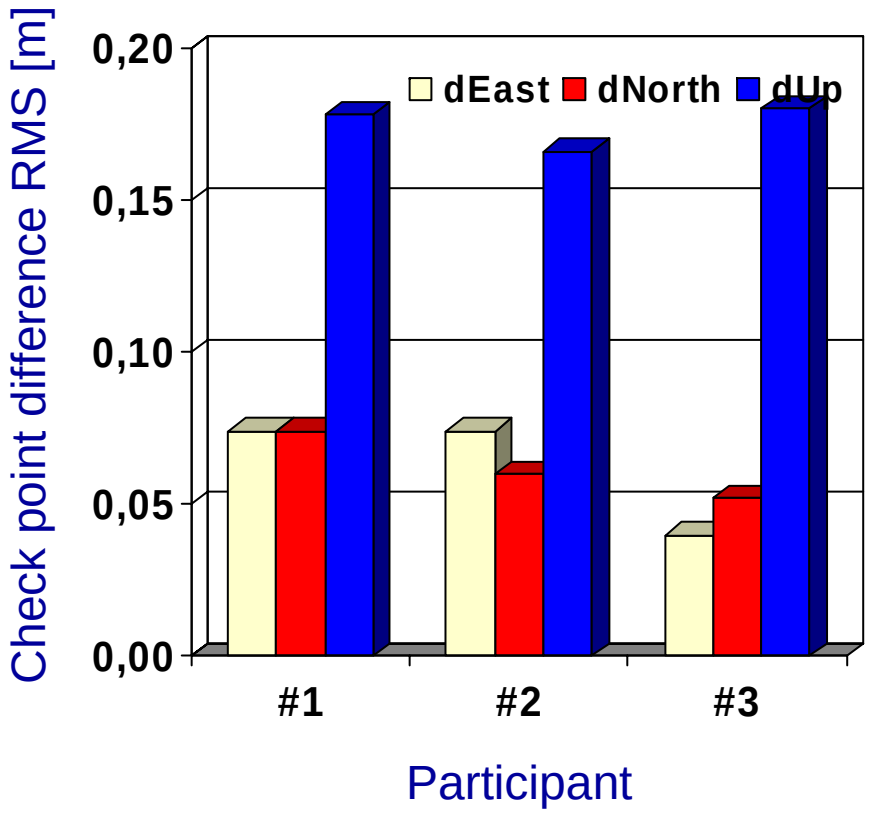
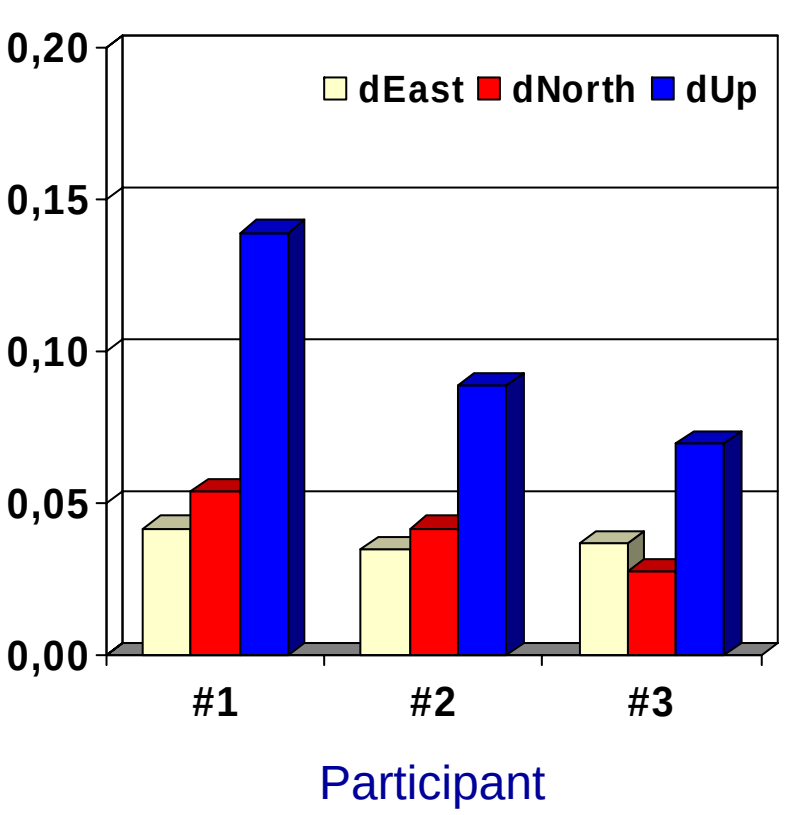
DMC high-altitude flight



RMS from 18 / 20 ChPs

DMC low-altitude flight



RMS from 19 / 21 ChPs

Phase II
Ongoing and future work

- What will pilot centre **derive** from participants input ?
  - compilation of comprehensive report
    - technical part
      - documentation of experimental phase 2 data & results
      - comparison of camera specific results
      - analogies in evaluation strategies and modeling
    - further experiences based on individual users input
    - derivation of recommendations for „optimal“ camera specific processing work flow
  - official publication in conference proceedings and / or journal in close cooperation with network participants
- And what is coming next ?
  - second experimental round in Phase II
    - alternative data sets, other aspects: radiometry, color, resolution
  - New project covering certification aspects ?

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USGS

Calibration & Validation of digital airborne cameras

US activity on certification and product characterization

*"**Sensor** and **processing** are important for the final **product**"*

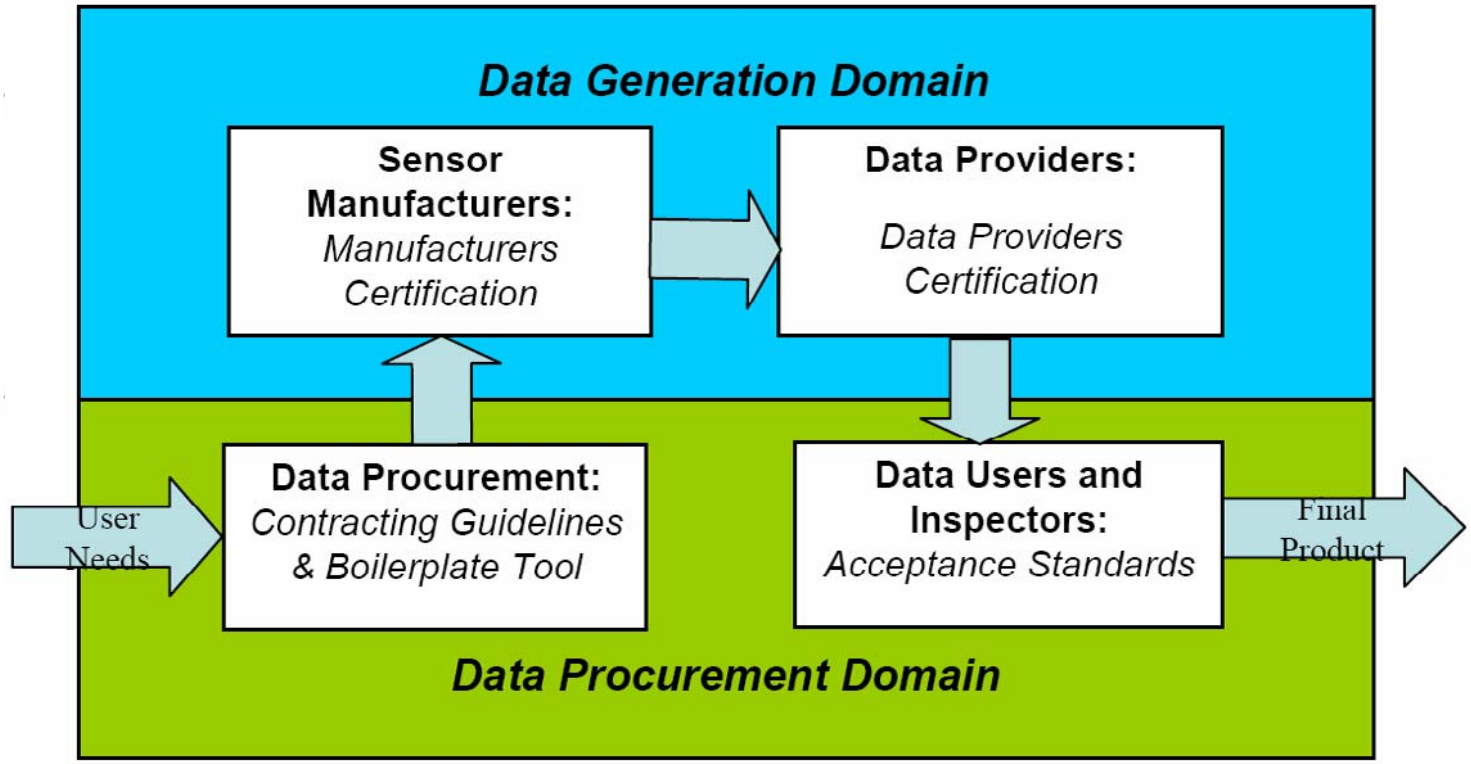
USGS Plan for Quality Assurance

- **Four major parts covering two major processes:**
  - **Data Production:**
    - Manufacturers Certification
    - Data Providers (flyers) Certification
  - **Data Purchasing & Acceptance**
    - Contracting Guidelines
    - Data Acceptance Standards

USGS

USGS Plan for Quality Assurance

- **Four major parts covering two major processes:**



USGS

Benefits of Manufacturers Certification

- Communicates specifications
- Provides evidence of system performance
- Independent certification helps to promote sensor systems
- Type certification eliminates burden of calibration for each sensor sold in the United States (1 time *vs.* n times)
- Eliminates need for USGS to have custom-built calibration instrument for calibration purposes

USGS

Benefits of Data Providers Certification

- Provides evidence of performance of products
- Independent certification helps to promote product specifications and Data Provider's capabilities
- Documents Data Provider's quality assurance plan and "best practices"
- One certification for Data Provider and not for each camera
- Data Providers no longer have to send cameras to OSL for calibration, reducing down-time and shipping expenses

USGS

Summary

- Digital airborne imaging is an exiting very viable field
- ongoing development of new systems and re-design of already existing ones
- there definitely will be more types of future applications, growing need for airborne imagery
- still there is the need for optimizing systems itself and even more the process flows

- **digital imaging has to be encouraged**
- transfer of **knowledge** and **experience** is of importance
- **your active support is needed** for current QA/QC initiatives and standardization activities

Special thank needs to be expressed to
USGS and the **active participants** within the
Phase II EuroSDR Camera Calibration network

Please try

http://calval.cr.usgs.gov

http://www.ifp.uni-stuttgart.de/EuroSDR

for more information

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