ifp

Universität Stuttgart

EuroSDR network

Digital Camera Calibration

Michael Cramer

michael.cramer@ifp.uni-stuttgart.de

XXth ISPRS congress 2004
Istanbul, Turkey, SS 13, July 22

www.ifp.uni-stuttgart.de/eurosdr/

Analogue airborne cameras

Universität Stuttgart

ZI-Imaging RMK Top

Leica RC 30

	ZI-Imaging [1]	Leica [2]
Camera name	RMK Top	RC 30
Image format [cm²]	23 x 23	23 x 23
Optics	Pleogon A3	UAG-S
Focal length [cm]	15	15
Field of view [gon]	82	82
Apertures	1:4 – 1:22	1:4 – 1:22
Exposure time [s]	1/50 – 1/1000	1/100 – 1/1000
Film length [m]	150	120
min. Image cycle [s]	1.5	2
Overall weight [kg] [3]	~ 134	~ 130

[1] ZI-Imaging formerly Carl Zeiss
[2] Leica Geosystems formerly LH-Systems, Wild
[3] incl. mount, film magazine, control unit
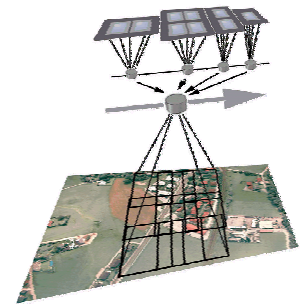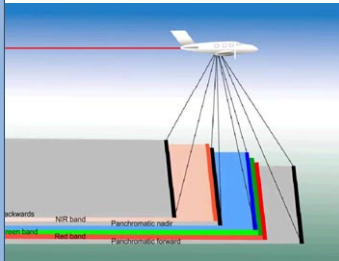
Digital airborne imaging
Systems I

Universität Stuttgart

ADS40 – Leica

DMC – ZI-Imaging

UltraCam$_D$ – Vexcel

Digital airborne imaging
Systems II

Universität Stuttgart

Starimager – Starlabo
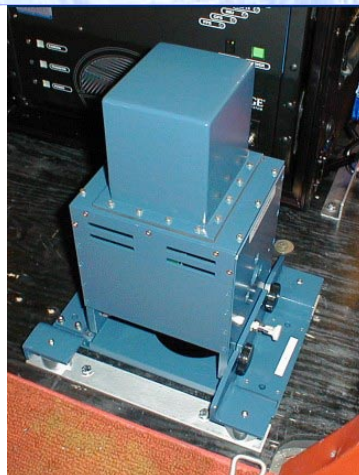
DSS – Applanix/Emerge

IGN – System

DIMAC – Cicade
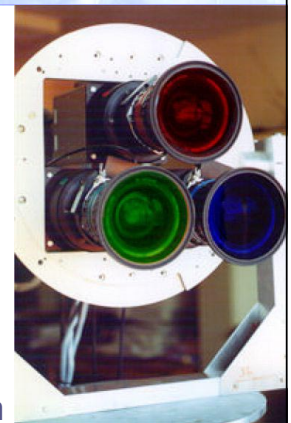
HRSC-A – DLR

non-dedicated airborne systems

System architectures

#	Sensor	Geometry		Sensor head		Image format		Image recording	
		Line	Frame	Single	Multi	large	me-dium	syn-chr.	syn-top.
1	ADS 40	X		X		X		X	
2	DMC		X		X	X		X	
3	UltraCam		X		X	X			X
4	DSS		X	X			X	X	
5	HRSC-Ax	X		X		X		X	
6	DIMAC		X	X	X		X	X	
7	IGN		X	X	X		X	X	

Camera calibration – Definitions
Manual of photogrammetry

- Camera calibration is the process whereby the geometric aspects of an individual mapping camera are determined.

- It is performed in the order that the photo obtained with the camera is used to produce accurate maps, to allow measurements, whereby ground distances or elevations can be obtained and to make orthophotos.

- It is possible to perform calibration to some order on any camera, but the cameras used to obtain the most accurate geometric data are specially designed for that purpose.

- Calibration assumes, that the thing being calibrated is stable between calibrations.

- Calibrated values and their accuracy are reported in a camera calibration certificate with tables and graphs.
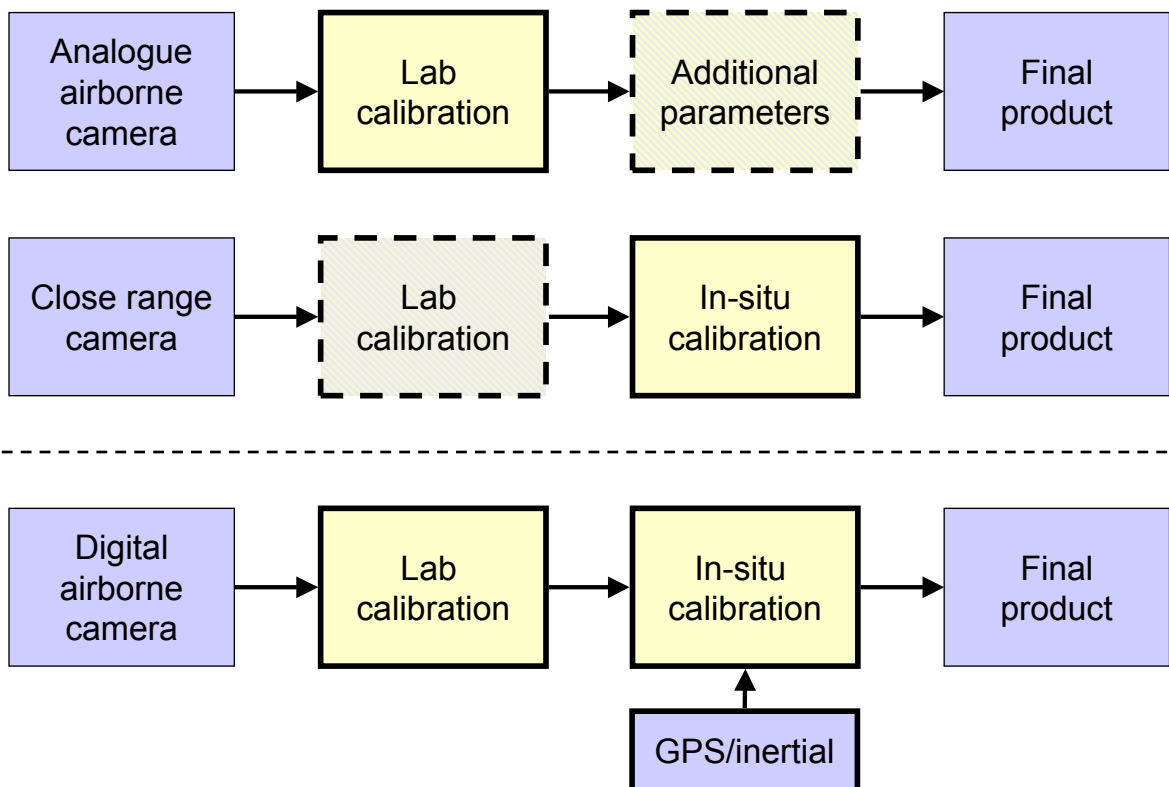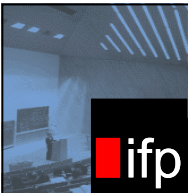
Universität Stuttgart

Lab calibration
Calibration facility at Carl Zeiss, Oberkochen

ifp

Universität Stuttgart

Calibration steps

ifp

Universität Stuttgart

| Analogue airborne camera | → | Lab calibration | → | Additional parameters | → | Final product |

| Close range camera | → | Lab calibration | → | In-situ calibration | → | Final product |

| Digital airborne camera | → | Lab calibration | → | In-situ calibration | → | Final product |

GPS/inertial

Objectives

▶ **PHASE 1**

Collection of publicly available material to compile an extensive report documenting currently used calibration practice and methods

- All network participants, i.e. camera producers and other experts contribute with their experiences
- Common knowledge base for the formulation on future strategies
- Helpful for system users to gain their experience with digital camera calibration
- Report is open to producers, users and customers

▶ **PHASE 2**

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

- Phase 2 design discussed on results of Phase 1
- 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
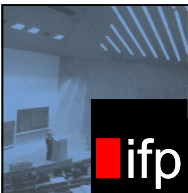

Road map

| Phase 1 | Oct '03 |
| Apr '04 |
| Jul '04 |
| Phase 2 |
| Jul '05 |

- Official project launch at October 17th, 2003
  - Start collecting publicly available material/experiences with recommendations of camera producers and other experts
- Compilation and distribution of report on currently used practice and methods of digital camera calibration
- Evaluation meeting of core network
- Presentation of results of Phase 1 at 104th EuroSDR meeting Denmark and ISPRS congress Turkey
- Experimental test and investigations
  - Final road map based on results of Phase 1, i.e.
    - testing and development of accepted procedures
    - design for optimal calibration flights
    - geometry, radiometry and image quality
    - stability and repeatability aspects
- Compilation of final report on results of empirical test
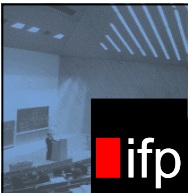
Network members

#	Group	Representatives	#
1	Camera manufacturers	ADS, DIMAC, DMC, DSS, UltraCamd, Starimager	11
2	Software developers	Bingo, Bluh, Orima	3
3	Other companies	Vito, McDonaldDettwiller, OMC	3
4	Universities	ETH, OSU, Glasgow, Stuttgart, Rostock	13
5	NMAs	ICC, USGS, OrdSurv, IGN, FGI, NLH, Swedish LandSurvey, Swisstopo	9
		Σ	39

Universität Stuttgart

Digital airborne sensor calibration
Today's situation

- **ADS 40**
  - Coded vertical goniometer (lab)
  - Calibration flights for self calibration (SC)
    - in future potentially based on SC only

- **DMC**
  - Goniometer (lab)
    - Calibration for each camera head individually
    - necessary for distortion free large format virtual image
  - Platform calibration during flights via tie point matching

- **UltraCamD**
  - Terrestrial test site calibration (lab) for each camera head
  - Relative orientation of cones from tie point for each mission flight

Universität Stuttgart

Phase 1
Current Status

▶ Final report Phase 1
- Based on ISPRS paper, already covers major findings of Phase 1
- Extended with …
  - outcome/discussions at EuroSDR meetings in Stuttgart and Copenhagen
  - personal correspondences with manufacturers and other experts at ISPRS congress
- Distribution of final report in October '04

▶ Bibliography
- Relevant project publications available on request
- should be made available digitally
 - literature research sometimes quite difficult

---

Phase 2
Planning

▶ Recommendations on optimal calibration strategies for each individual camera where EuroSDR serves as independent organization

- Focus on following calibration and validation aspects
  - Does camera geometry work ?
  - Does camera radiometry work ?
  - Does camera colour work ?

- Aspects of geometry and spatial resolution investigated first

- Pan-chromatic data used for geometric resolution tests

- What kind of data should be distributed ?

Universität Stuttgart

Phase 2
Test flight data base

- NLH test flights in southern Norway (test site Fredrikstad)
  - ADS40, September 9, 2002
  - DMC, August 10 & October 10, 2003
  - UltraCamD, May 2, 2004

- ifp tests in southern Germany (test site Vaihingen/Enz)
  - ADS40, June 26, 2004
  - Test sponsored by Leica Geosystems

- FGI test flights in southern Finland (test site Sjökulla)
  - DMC (+ HRSC-AX), scheduled August 2004

- Other flight test, i.e.
  - Ordnance Survey, Swedish Land Survey ?
  - Other NMA or customer flights ?

Universität Stuttgart
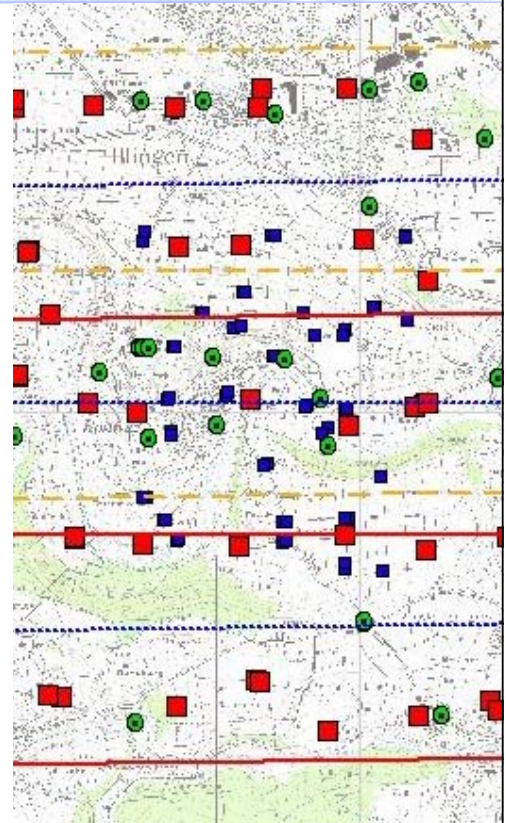
Conclusion & future trends

- System driven approaches are gaining in importance compared to individual components calibrations

- Decrease of importance in lab calibrations seems to be visible, where need for of in-situ calibrations increases

- Combined lab and in-situ calibration will be accepted as powerful and efficient tool for overall system calibration and validation

Universität Stuttgart

Final Announcement

- **_All experts_** in Digital Airborne Camera Calibration are invited to join this EuroSDR network !

- Please support our project with your expertise!

- Active Participation in upcoming Phase 2 is still possible and always welcomed

▶ **_Please comment now !_**

Michael Cramer (contact)

Institute for Photogrammetry (ifp) – University of Stuttgart

Geschwister-Scholl-Straße 24 D, 70174 Stuttgart / Germany

michael.cramer@ifp.uni-stuttgart.de

www.ifp.uni-stuttgart.de/eurosdr/

Universität Stuttgart