



Digital Airborne Camera Performance – The DGPF test Overview and results

Michael Cramer

Photogrammetric Week
2009

Stuttgart
September 8, 2009



The EuroSDR Performance Test for Digital Aerial Camera Systems

EuroSDR network on Digital Camera Calibration and Validation



Michael Cramer

michael.cramer@ifp.uni-stuttgart.de

51st Photogrammetric Week

September 3 – 7, 2007

Universität Stuttgart

Empirical Evaluation Tests

EuroSDR (2007) vs. DGPF (2009)



www.ifp.uni-stuttgart.de/dgpf

Universität Stuttgart

	EuroSDR test	DGPF
Acquisition Time	10/2003, 06/2004, 09/2004	July – September 2008
Test site	Vaihingen/Enz (1x) Fredrikstad (2x)	Vaihingen/Enz
Sensor systems	ADS40 (1st), DMC, Ultracam-D	ADS40 (2nd), DMC, Ultracam-X, JAS-150, Quattro DigiCAM, AIC-x1, DLR 3K, RMK-Top, ALS50, AISA, ROSIS, Spectrometer
Research topics	Geometry	Geometry, Radiometry, DSM Generation, Stereoplotting
Active participants	13 groups/institutions (European)	30 groups/institutions (German speaking countries)

Institut für Photogrammetrie



Universität Stuttgart

Digital Airborne Camera Performance – The DGPF test

Overview and results

The DGPF test design



The DGPF-Test Objectives & Organization



www.ifp.uni-stuttgart.de/dgpf

Universität Stuttgart

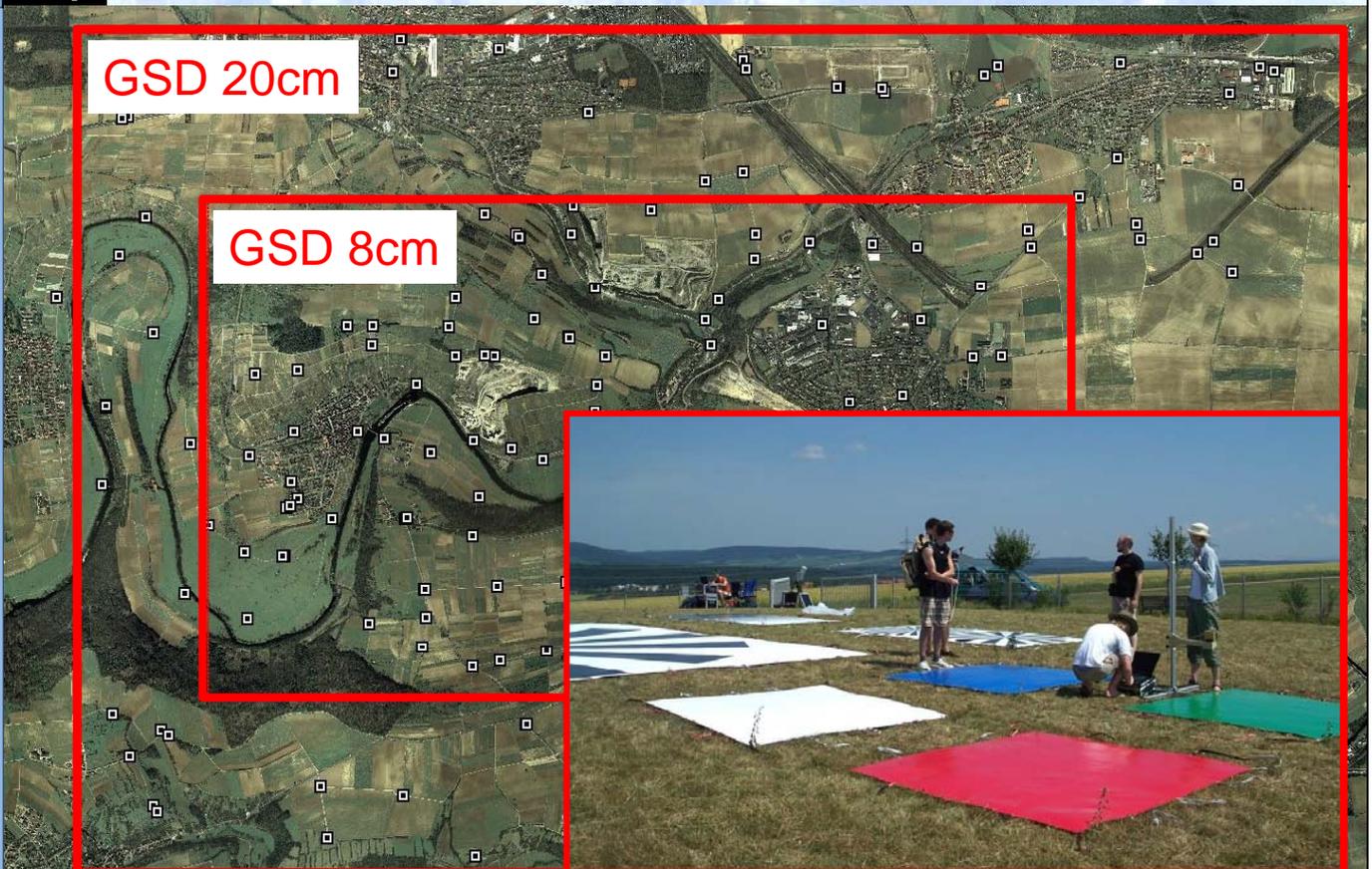


- **User driven** independent and objective evaluation of commercially available digital photogrammetric camera systems (focus on **airborne** and **large format**)
- Follow-up of already done national or international evaluation projects (like **EuroSDR network Digital Camera Calibration**)
- Evaluation of **sensor specific strengths and potential weaknesses, no direct comparison** between performance of different sensors!
- Processing teams focussing on different topics
 - Team 1: **Geometric accuracy and resolution** (▶ **K. Jacobsen**)
 - Team 2: **Radiometric accuracy** (▶ **M. von Schönermark**)
 - Team 3: **Automatic DSM generation** (▶ **N. Haala**)
 - Team 4: **Stereoplotting** (▶ **V. Spreckels**)

Test site Vaihingen/Enz Institut für Photogrammetrie (ifp)



Universität Stuttgart



Reference data Test field layout



Ground references

- Spectrometer measurements in field, sunphotometer
- BRDF measurements
- Manual, on-site land use classifications (multiple days)



DGPF evaluation test Vaihingen/Enz test flight data

System	System provider	Flyer	Date of flight(s)
DMC	Intergraph/ZI	RWE Power	24.7.08 + 6.8.08
ADS 40, SH52	Leica Geosyst.	Leica Geosyst.	6.8.08
JAS-150	JenaOptronik	RWE Power	9.9.08
Ultracam-X	Vexcel Imaging	bsf Swissphoto	11.9.08
RMK-Top15	Zeiss	RWE Power	24.7.08 + 6.8.08
quattro DigiCAM, 4-Head	IGI	Geoplana	6.8.08
AIC-x1, 1-Head	Rolleimetric	Alpha Luftbild	11.9.08
AIC-x4, 4(3)-Head	Rolleimetric	Vulcan Air	19.9.08
DLR 3K-Camera	DLR Munich	DLR Munich	15.7.08
AISA+ hyper-spectral (parallel with DMC)	Specim/FH Anhalt	RWE Power	2.7.08
ROSIS hyper-spectral	DLR Munich	DLR Munich	15.7.08
ALS 50 LiDAR	Leica Geosyst.	Leica Geosyst.	21.8.08



Block design

DMC & UCX GSD 20cm / GSD 8cm



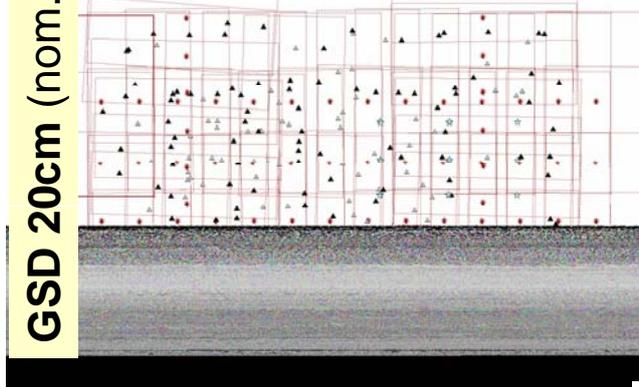
www.ifp.uni-stuttgart.de/dgpf

Universität Stuttgart

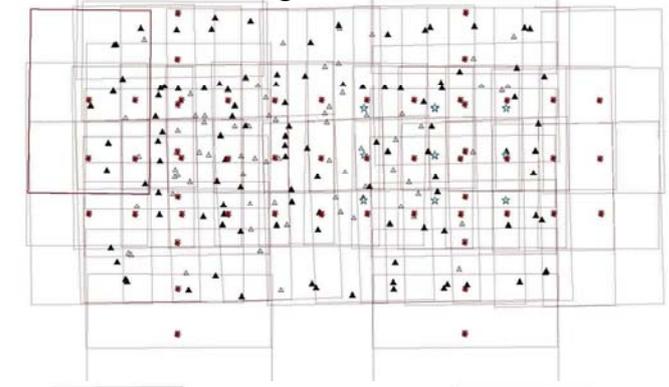


GSD 20cm (nom.)

DMC – hg 2160m, **60/60**

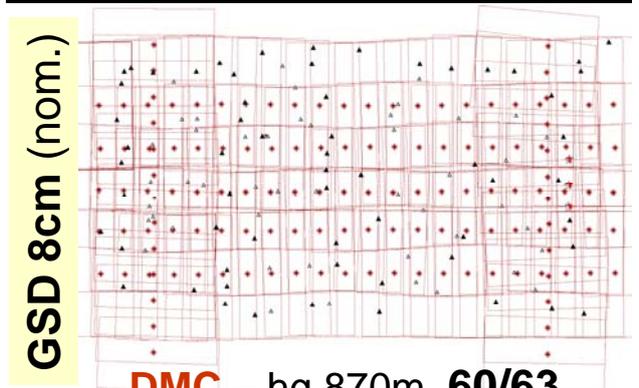


UCX – hg 2900m, **70/70**

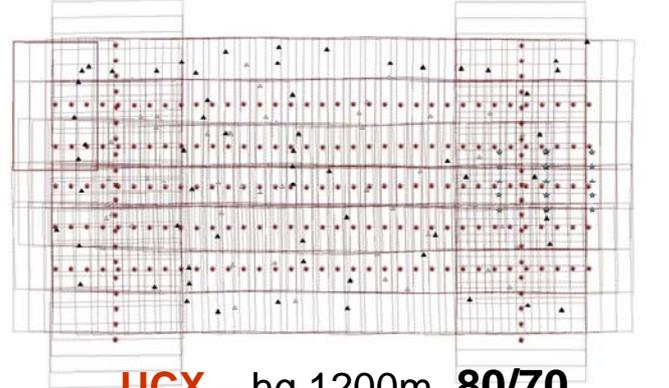


GSD 8cm (nom.)

DMC – hg 870m, **60/63**



UCX – hg 1200m, **80/70**



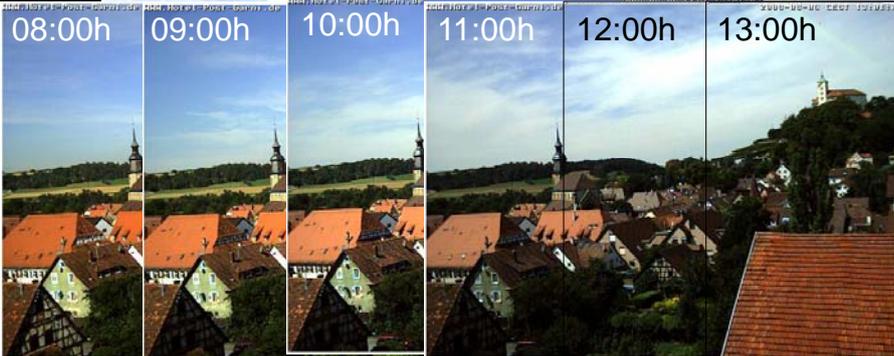
Sunphotometer & WebCam

Day of flight 6. August 2008



www.ifp.uni-stuttgart.de/dgpf

Universität Stuttgart



Aerosol optical depth
@ 534nm

DMC

quattro DigiCAM

ADS40 SH52

Time [UTC]

Digital Airborne Camera Performance – The DGPF test

Overview and results

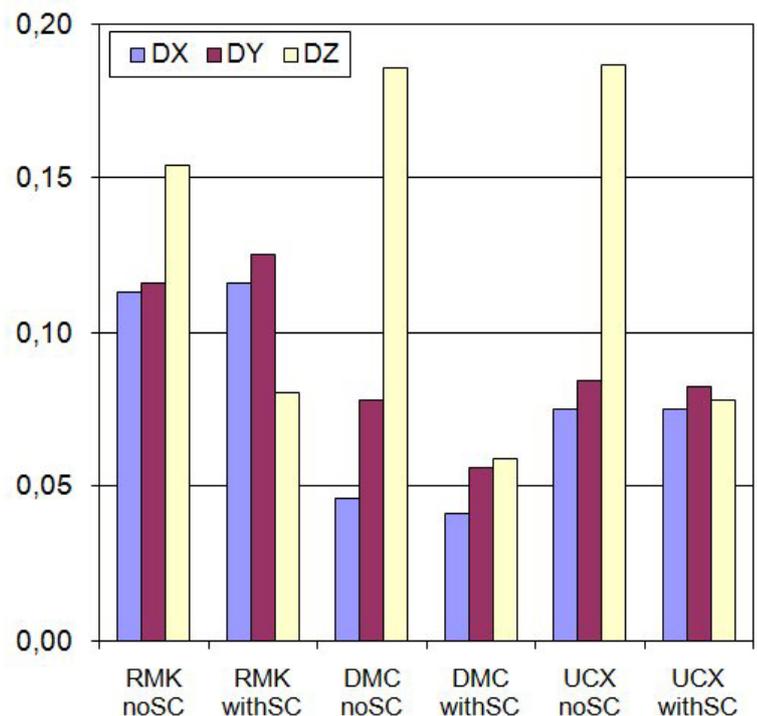
Results from geometric performance analysis



Impact of Self Calibration – GSD 20cm

Frame Sensors

Block	#GCP / h_g p / q [%]
RMK Uni Hann. no SC	14 / 2160m 60 / 70
RMK Uni Hann. 12 BLUH par.	14 / 2160m 60 / 70
DMC Uni Hann. no SC	9 / 2160m 60 / 60
DMC Uni Hann. 12par.+2 DMC	9 / 2160m 60 / 60
UCX Uni Hann. no SC	9 / 2900m 70 / 70
UCX Uni Hann. 12par.+32 UC	9 / 2900m 70 / 70



BLUH results from IPI, Uni Hannover

RMS from ChP [m]

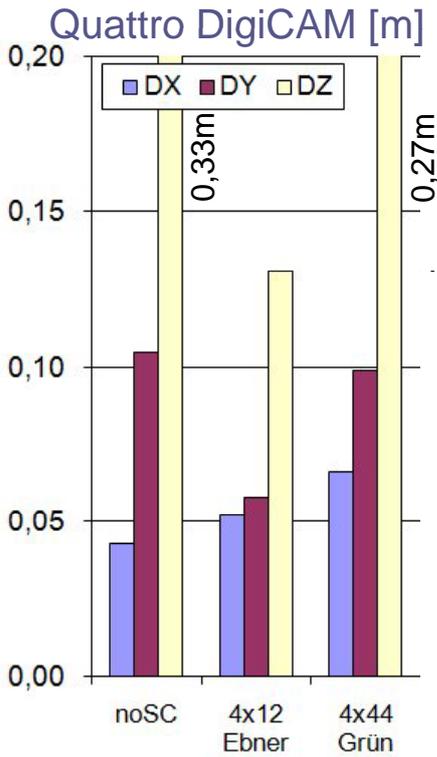


Impact of Self Calibration – GSD 20cm Frame Sensors

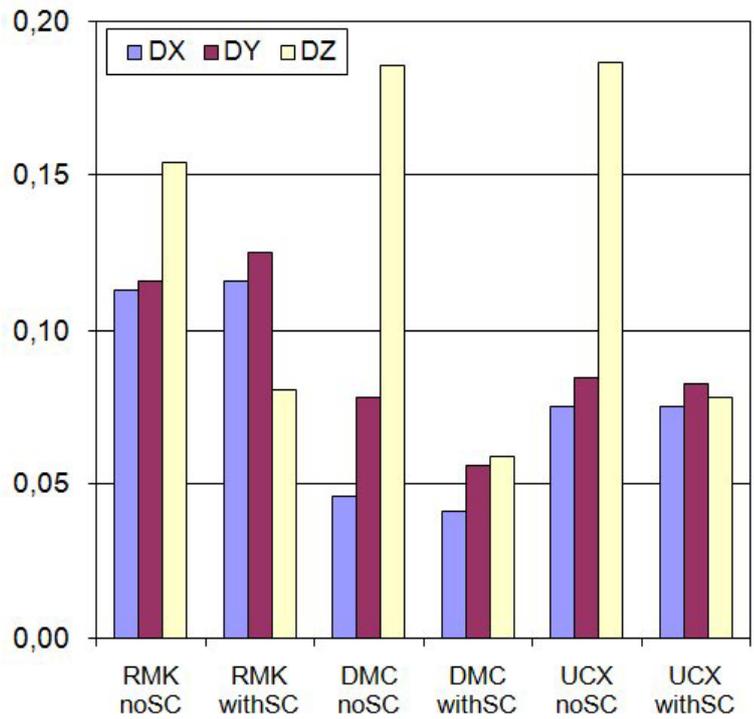


www.ifp.uni-stuttgart.de/dgpf

Universität Stuttgart



RMS from ChP [m]



RMS from ChP [m]



Absolute Object Point Accuracy – GSD 20cm Frame Sensors

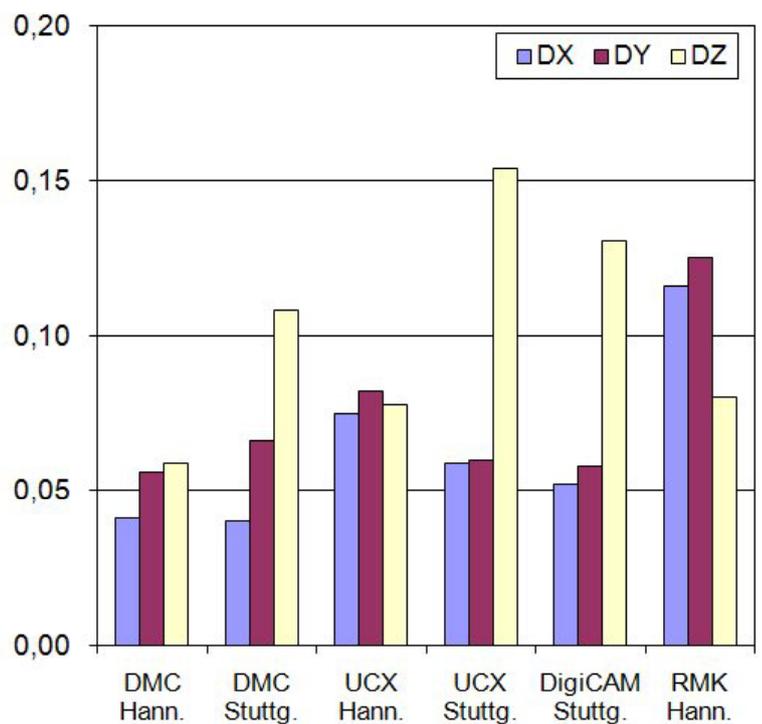


www.ifp.uni-stuttgart.de/dgpf

Universität Stuttgart



Block	#GCP / h_g p / q [%]
DMC Uni Hann. 60 photos	9 / 2160m 60 / 60
DMC Uni Stuttg. 42 photos	4 / 2160m 60 / 60
UCX Uni Hann. 52 photos	9 / 2900m 70 / 70
UCX Uni Stuttg. 36 photos	4 / 2900m 70 / 70
IGI Uni Stuttg. 132 photos	4 / 2500m 60 / 70
RMK Uni Hann. 47 photos	14 / 2160m 60 / 70



RMS from ChP [m]

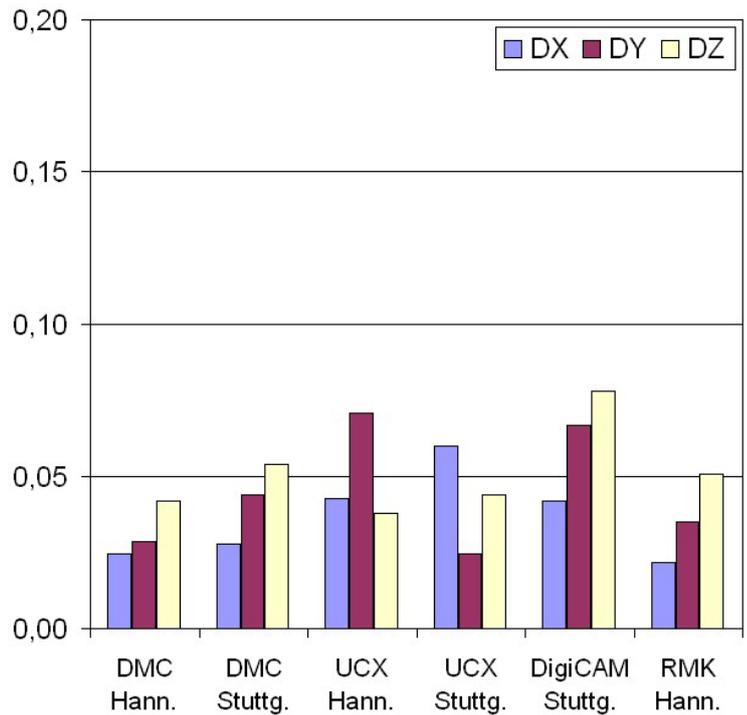
Absolute Object Point Accuracy – GSD 8cm Frame Sensors



www.ifp.uni-stuttgart.de/dgpf

Universität Stuttgart

Block	#GCP / h_g p / q [%]
DMC Uni Hann. 135 photos	9 / 1200m 60 / 63
DMC Uni Stuttg. 110 photos	4 / 1200m 60 / 63
UCX Uni Hann. 215 photos	9 / 1200m 80 / 70
UCX Uni Stuttg. 175 photos	4 / 1200m 80 / 70
IGI Uni Stuttg. 640 photos	4 / 1060m 80 / 70
RMK Uni Hann. 74 photos	870m 60 / 70



RMS from ChP [m]

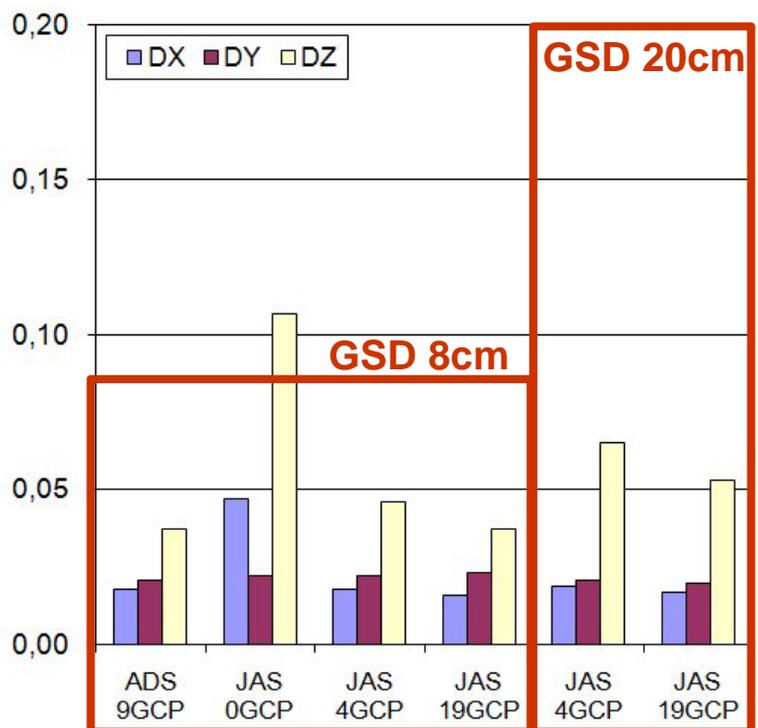
Absolute Object Point Accuracy Line Scanners



www.ifp.uni-stuttgart.de/dgpf

Universität Stuttgart

Block	# GCP / Height h_n
ADS Uni Hann. GSD 8cm	9 / 1900m
JAS RAG Herne GSD 8cm	0 / 1800m
JAS RAG Herne GSD 8cm	4 / 1800m
JAS RAG Herne GSD 8cm	19 / 1800m
JAS RAG Herne GSD 20cm	4 / 4600m
JAS RAG Herne GSD 20cm	19 / 4600m



RMS from ChP [m]





Digital Airborne Camera Performance – The DGPF test Overview and results

Some results from other processing teams

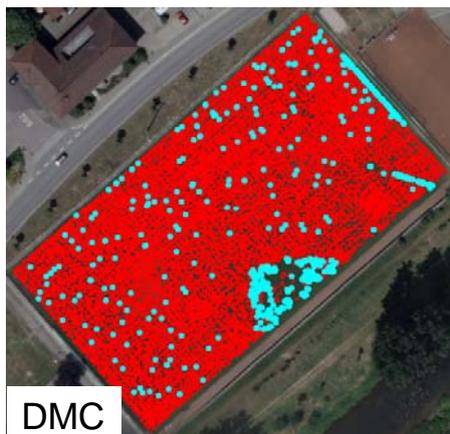


Analysis of 3D point clouds *Sports field (images at GSD 8cm)*

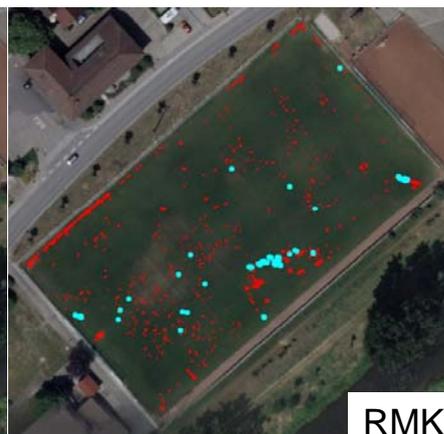


Sportsfield

- DSM accuracy **DMC**
 - Std.Dev.= 5.2cm, Density= 19.7 Pts/m²
- DSM accuracy **RMK**
 - Std.Dev. = 17.2cm, Density = 0.8 Pts/m²
- Laserscanner (ALS50) – Reference
 - Std.Dev.= 1.9cm, Density = 8.3 Pts/m²



DMC



RMK



ALS50

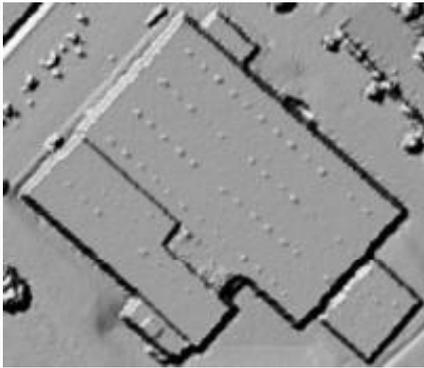
Automatic DSM generation (buildings)

Results from ETH Zürich

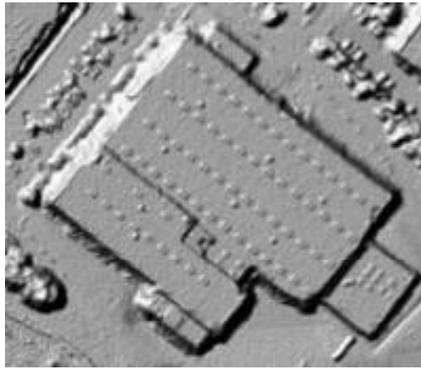


www.ifp.uni-stuttgart.de/dgpf

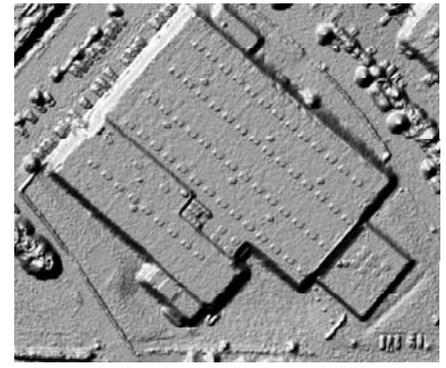
Universität Stuttgart



ALS50 reference
DSM 25cm grid



DMC GSD 8cm
6-folded overlap



UCX GSD 8cm
10-folded overlap



DSM obtained from SAT-PP Software (ETHZ)

Test site industrial building

K. Wolff (ETH Zürich)

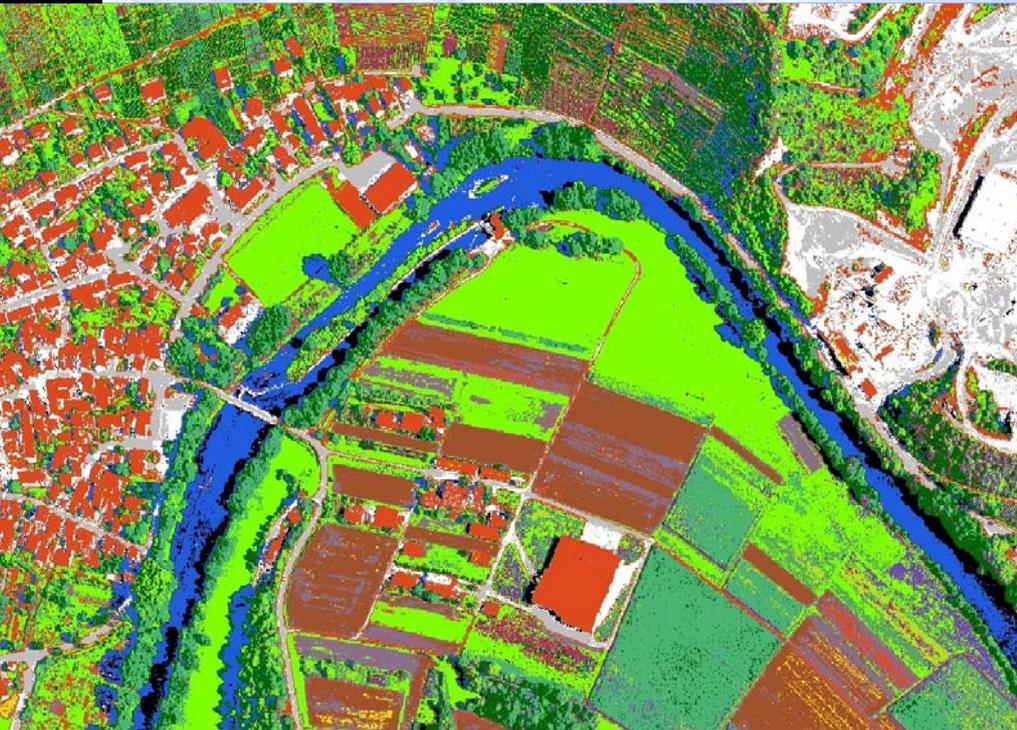


Automatic land-use classification



www.ifp.uni-stuttgart.de/dgpf

Universität Stuttgart



Results from DMC (GSD 20cm)

S. Klonus (IGF, Universität Osnabrück)





Digital Airborne Camera Performance – The DGPF test Overview and results

Summary



Conclusions (1/2)

- (geometric) performance of different sensors quite close
Abs. Accuracy (RMS) of object point determination
realistic control/block configuration $\sim \frac{1}{2}$ pix GSD
results underline the **high potential of digital image recording**
- Accuracy potential already **close to the accuracy of reference data** (i.e. control points, LiDAR data)
- Self-calibration (to certain extend) is necessary
- some differences in accuracy are present, but question whether they of **relevance for later practical operation or only academic discussion?**



Conclusions (2/2)



- **Other factors gain in importance** (environmental conditions, choice of reference data) and may have larger impact on final accuracy than choice of sensor system itself
- **Sensor and sensor related software chain** is tightly coupled and has to be considered
- All results rely on (one single) DGPF data set only – **transfer of results to later production environments?**



Acknowledgments



- system suppliers, mainly **Leica Geosystems, Intergraph / ZI-Imaging, Vexcel Imaging, Jenaoptronic, IGI, Rolleimetric**
- data providers & flying companies
- **DGPF project team leaders**, namely, K. Jacobsen, M. v. Schönermark, N. Haala & V. Spreckels.
- all supporting **project partners and participants**, represented by H. Krauß, K. Komp, E. Jordan, R. Wahmke, C. Hagedorn, K. Jacobsen, F. Rottensteiner, W. Stößel, S. Holzwarth, F. Kurz, M. v. Schönermark, V. Kaufmann, R. Ladstädter, M. Kähler, M. Breuer, C. Gläßer, A. Jung, S. Baltrusch, E. Wild, A. Grün, M. Baltsavias, A. Busch, F. Rückert, H. Hastedt, R. Schneider, V. Spreckels, T. Luhmann, P. Grussenmeyer, K. Clausen, N. Pfeiffer, T. Kersten, A. Fricker, W. Förstner, M. Gültlinger and others

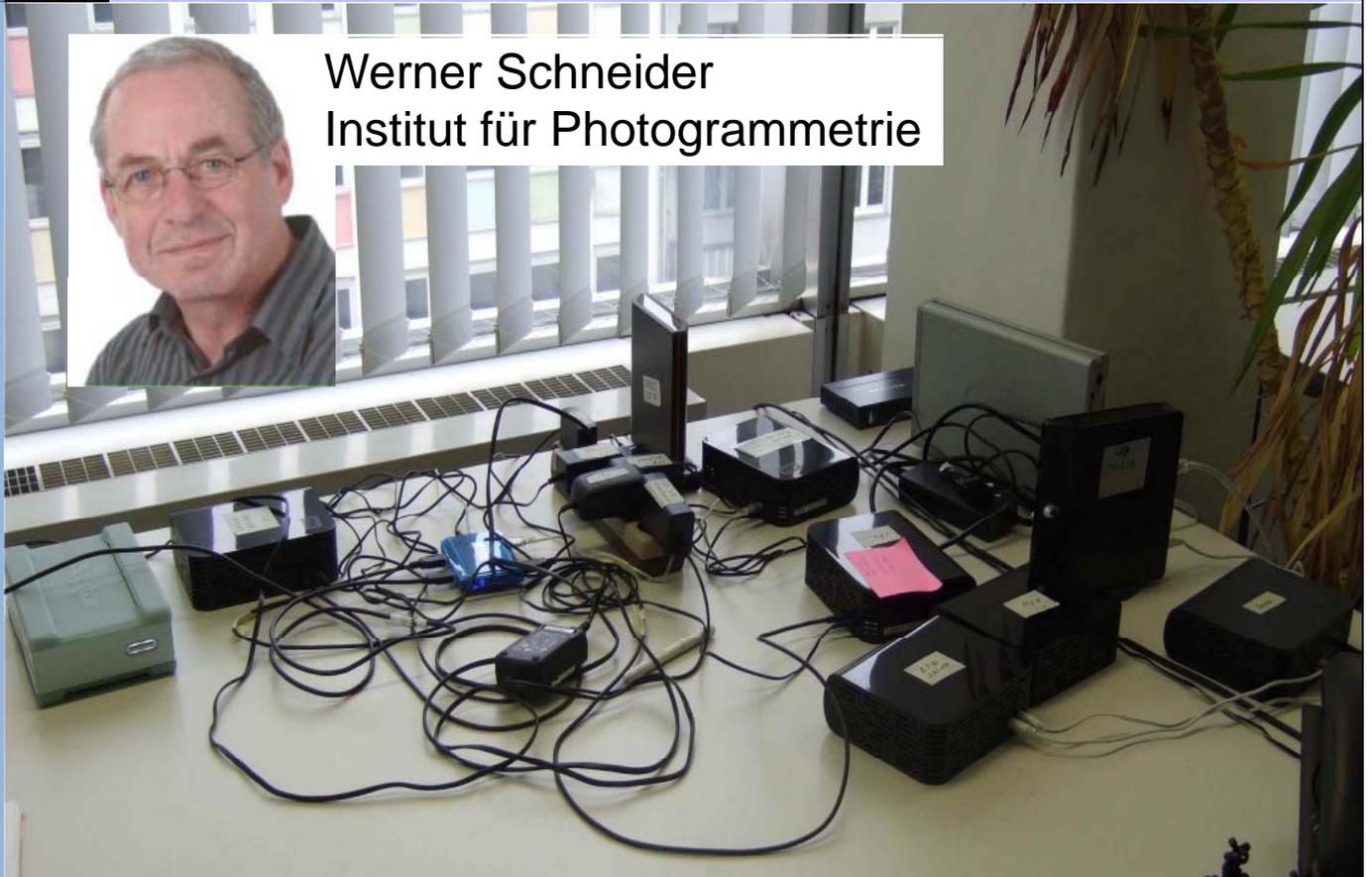


Acknowledgments



Werner Schneider
Institut für Photogrammetrie

Universität Stuttgart



Institut für Photogrammetrie



www.ifp.uni-stuttgart.de/dgpf

Universität Stuttgart



**Digital Airborne Camera
Performance – The DGPF test**
Overview and results

DGPF Project Meeting
October 5-6, 2009
Universität Stuttgart

see www.ifp.uni-stuttgart.de/dgpf