Creating virtually distortion free imagery

Geometric calibration of the Leica RCD30

Ruedi Wagner, Vice President Imaging
Udo Tempelmann, Head System Engineering
Leica Geosystems, Geospatial Solutions Division

WPU

12.2.2012

The power to see ZI IMAGING - when it has to be right Leica Geosystems

Content

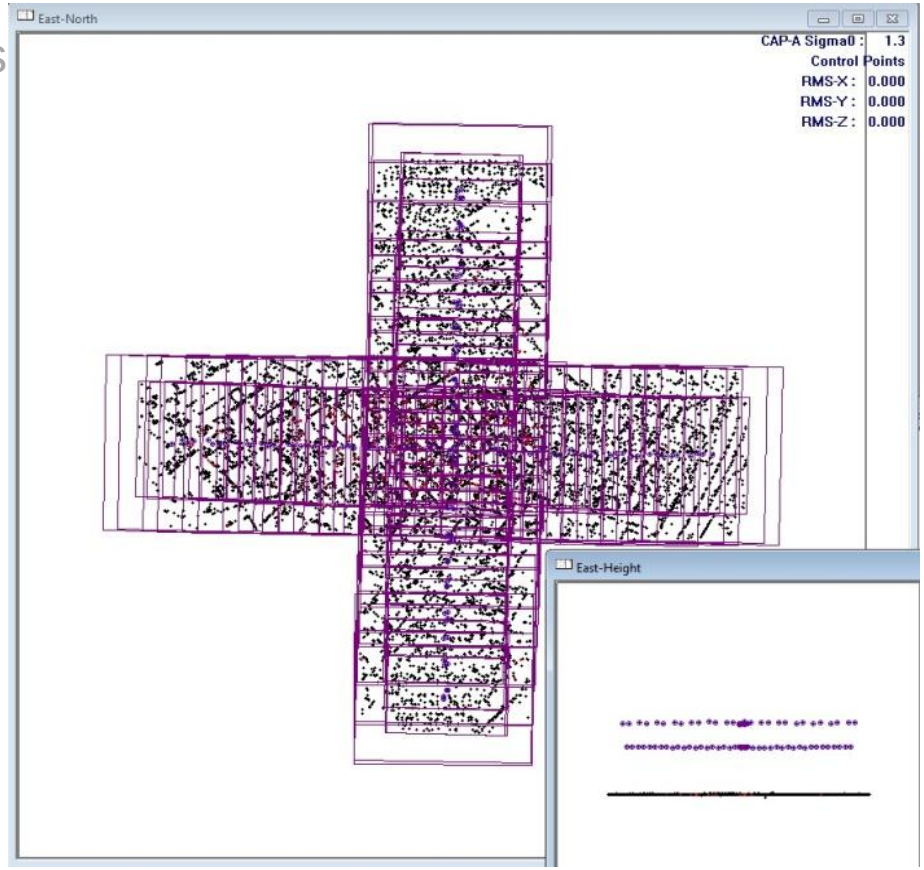
- RCD 30 sensor overview
- Photogrammetric flight calibration & grid based correction
- Goniometer approach, a small Leica history summary
- The RCD30 laboratory calibration

The power to see ZI IMAGING - when it has to be right Leica Geosystems

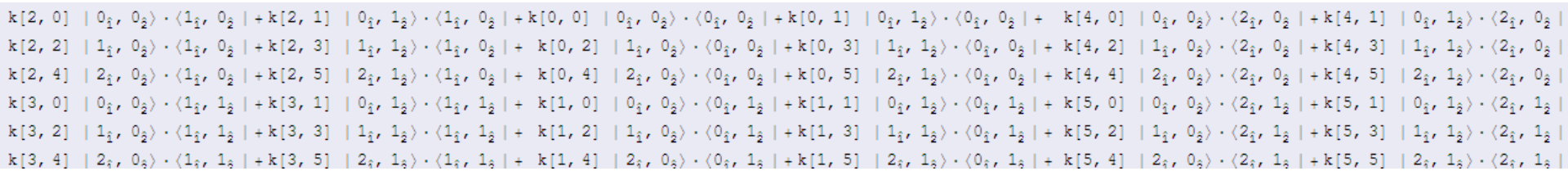
Flight based calibration

- Cross pattern at two different heights
- Symmetric, all line bi-directional
- Tie points with high number of rays
- GPS/IMU result from two heights allows calibration without ground control points

- Minimal correlation between camera parameters IMU misalignment and exterior orientation parameters



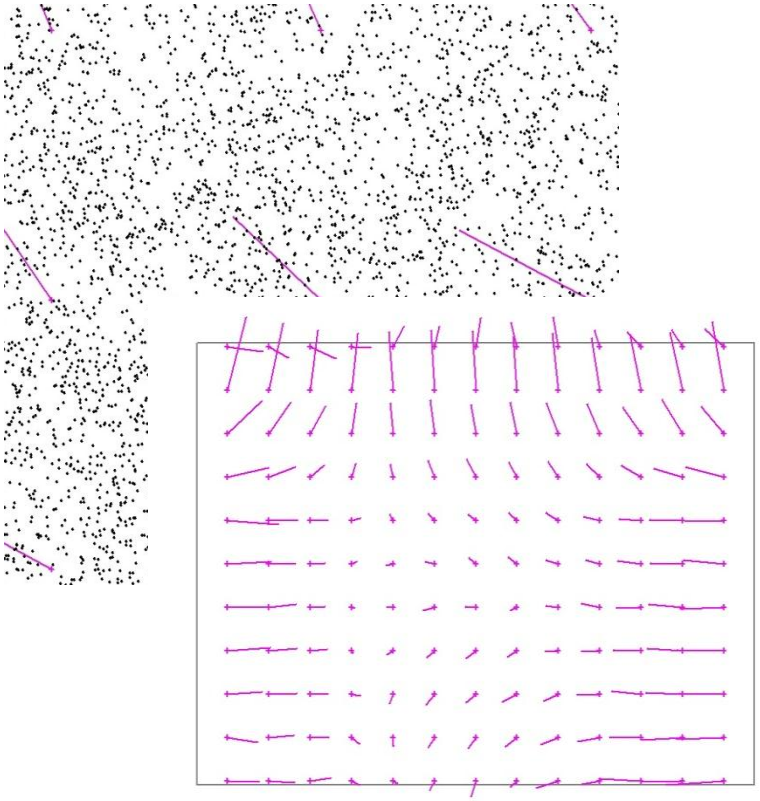
The power to see
- when it has to be right

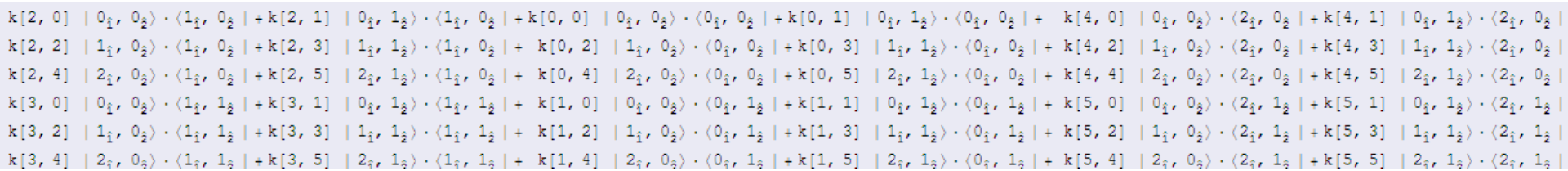


Flight based calibration, the bundle adjustment

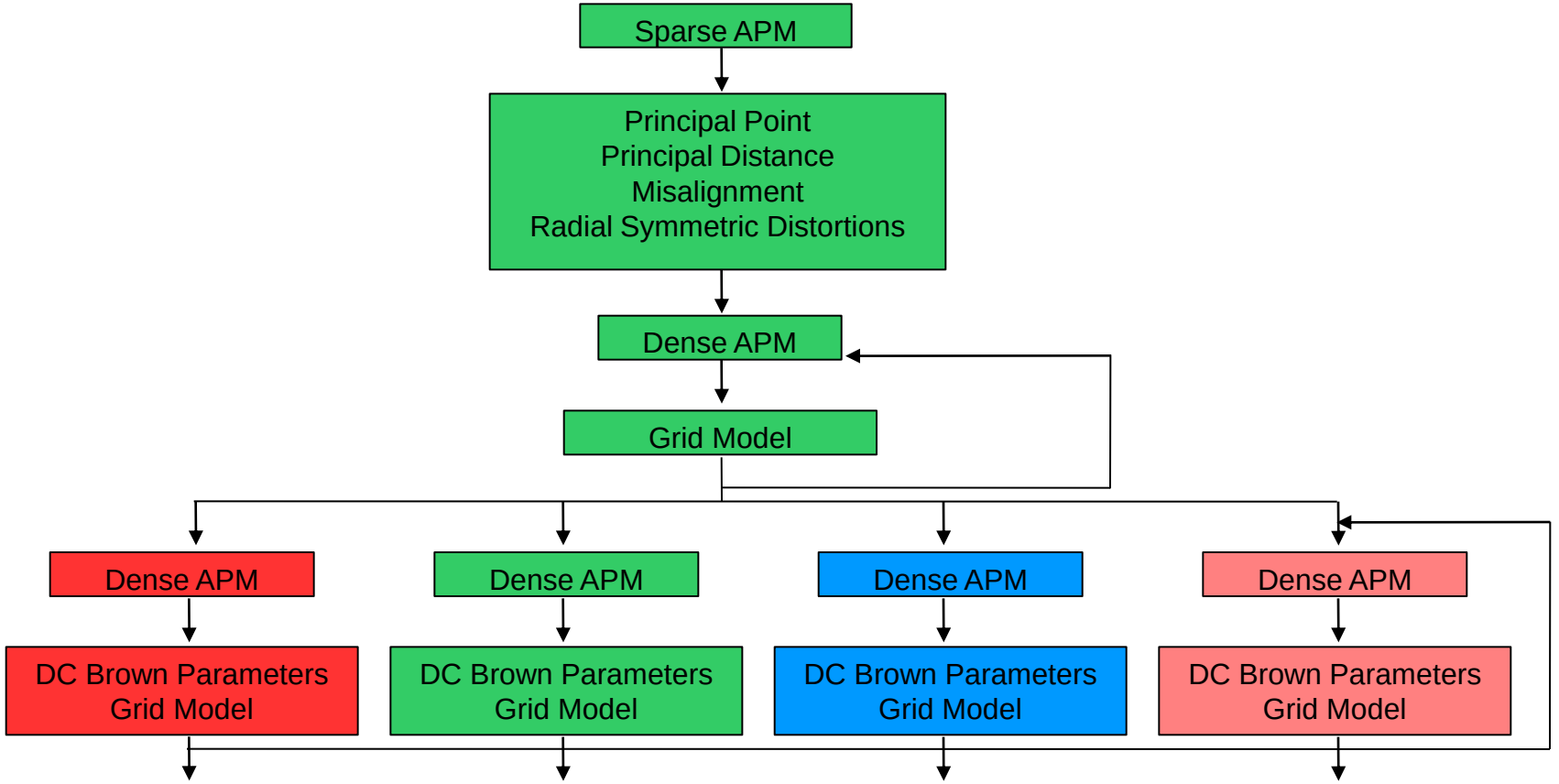
- DC Brown parameters used for the “classical” distortion model

- Grid estimation for local error
- → assumption error ≈ 0
- → integrated into the bundle
- → grid determined using the tie points of all images





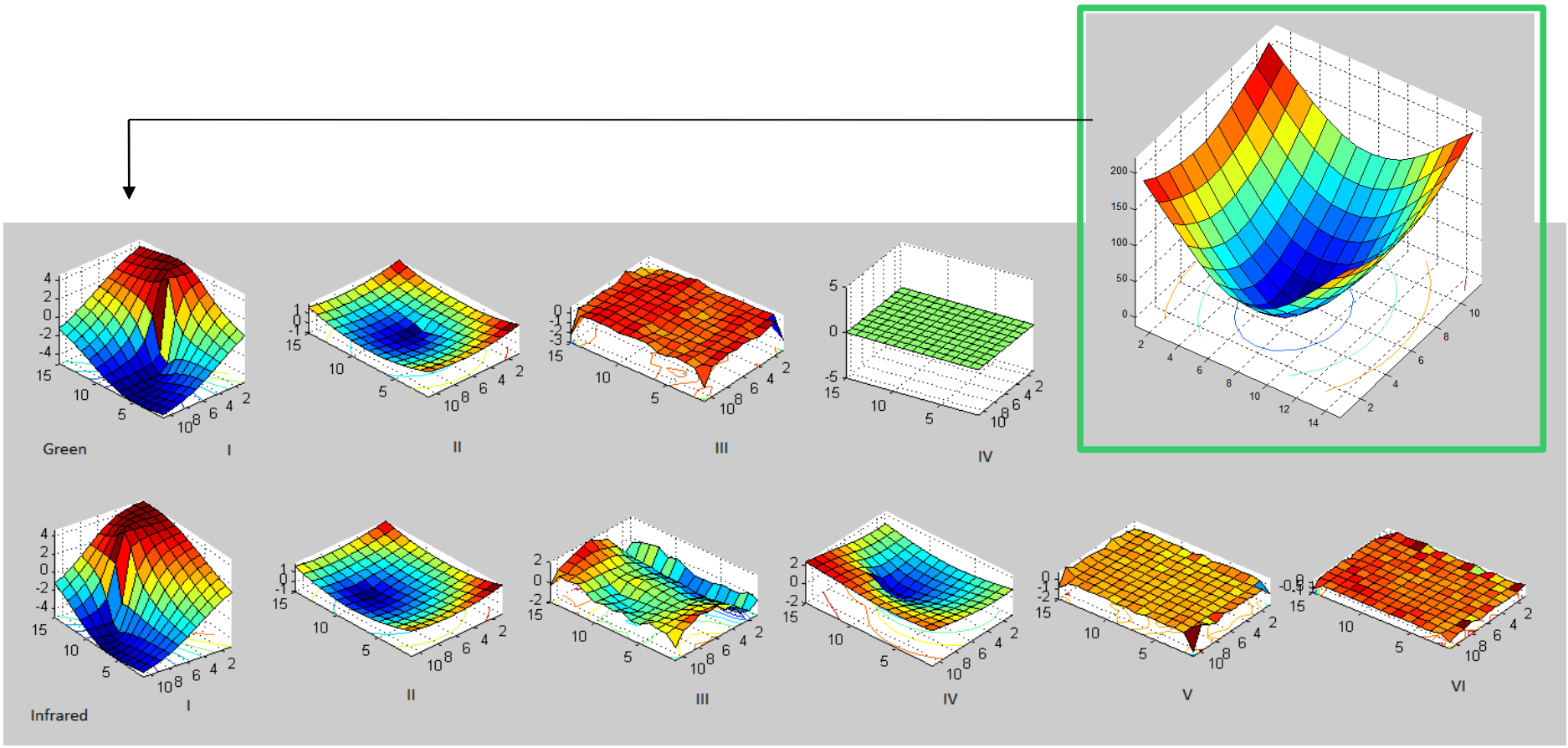
An iterative process



The power to see
- when it has to be right

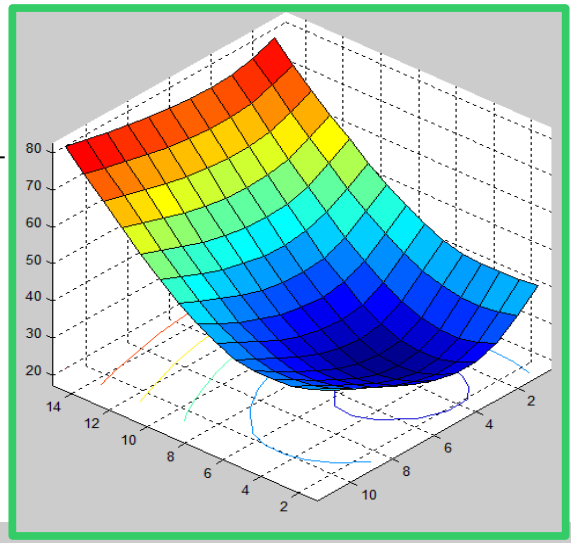
$$k[2,0]\,|0_i,0_s\rangle\cdot\langle 1_i,0_s| + k[2,1]\,|0_i,1_s\rangle\cdot\langle 1_i,0_s| + k[0,0]\,|0_i,0_s\rangle\cdot\langle 0_i,0_s| + k[0,1]\,|0_i,1_s\rangle\cdot\langle 0_i,0_s| + k[4,0]\,|0_i,0_s\rangle\cdot\langle 2_i,0_s| + k[4,1]\,|0_i,1_s\rangle\cdot\langle 2_i,0_s|$$
$$k[2,2]\,|1_i,0_s\rangle\cdot\langle 1_i,0_s| + k[2,3]\,|1_i,1_s\rangle\cdot\langle 1_i,0_s| + k[0,2]\,|1_i,0_s\rangle\cdot\langle 0_i,0_s| + k[0,3]\,|1_i,1_s\rangle\cdot\langle 0_i,0_s| + k[4,2]\,|1_i,0_s\rangle\cdot\langle 2_i,0_s| + k[4,3]\,|1_i,1_s\rangle\cdot\langle 2_i,0_s|$$
$$k[2,4]\,|2_i,0_s\rangle\cdot\langle 1_i,0_s| + k[2,5]\,|2_i,1_s\rangle\cdot\langle 1_i,0_s| + k[0,4]\,|2_i,0_s\rangle\cdot\langle 0_i,0_s| + k[0,5]\,|2_i,1_s\rangle\cdot\langle 0_i,0_s| + k[4,4]\,|2_i,0_s\rangle\cdot\langle 2_i,0_s| + k[4,5]\,|2_i,1_s\rangle\cdot\langle 2_i,0_s|$$
$$k[3,0]\,|0_i,0_s\rangle\cdot\langle 1_i,1_s| + k[3,1]\,|0_i,1_s\rangle\cdot\langle 1_i,1_s| + k[1,0]\,|0_i,0_s\rangle\cdot\langle 0_i,1_s| + k[1,1]\,|0_i,1_s\rangle\cdot\langle 0_i,1_s| + k[5,0]\,|0_i,0_s\rangle\cdot\langle 2_i,1_s| + k[5,1]\,|0_i,1_s\rangle\cdot\langle 2_i,1_s|$$
$$k[3,2]\,|1_i,0_s\rangle\cdot\langle 1_i,1_s| + k[3,3]\,|1_i,1_s\rangle\cdot\langle 1_i,1_s| + k[1,2]\,|1_i,0_s\rangle\cdot\langle 0_i,1_s| + k[1,3]\,|1_i,1_s\rangle\cdot\langle 0_i,1_s| + k[5,2]\,|1_i,0_s\rangle\cdot\langle 2_i,1_s| + k[5,3]\,|1_i,1_s\rangle\cdot\langle 2_i,1_s|$$
$$k[3,4]\,|2_i,0_s\rangle\cdot\langle 1_i,1_s| + k[3,5]\,|2_i,1_s\rangle\cdot\langle 1_i,1_s| + k[1,4]\,|2_i,0_s\rangle\cdot\langle 0_i,1_s| + k[1,5]\,|2_i,1_s\rangle\cdot\langle 0_i,1_s| + k[5,4]\,|2_i,0_s\rangle\cdot\langle 2_i,1_s| + k[5,5]\,|2_i,1_s\rangle\cdot\langle 2_i,1_s|$$

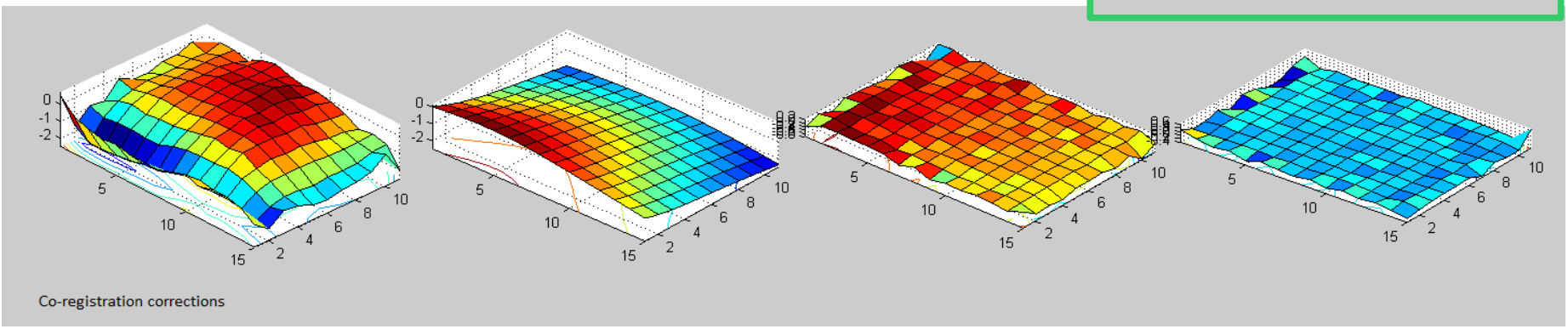
Bands corrected step by step



The power to see
ZI IMAGING
- when it has to be right
Leica Geosystems

Coregistration





Co-registration corrections

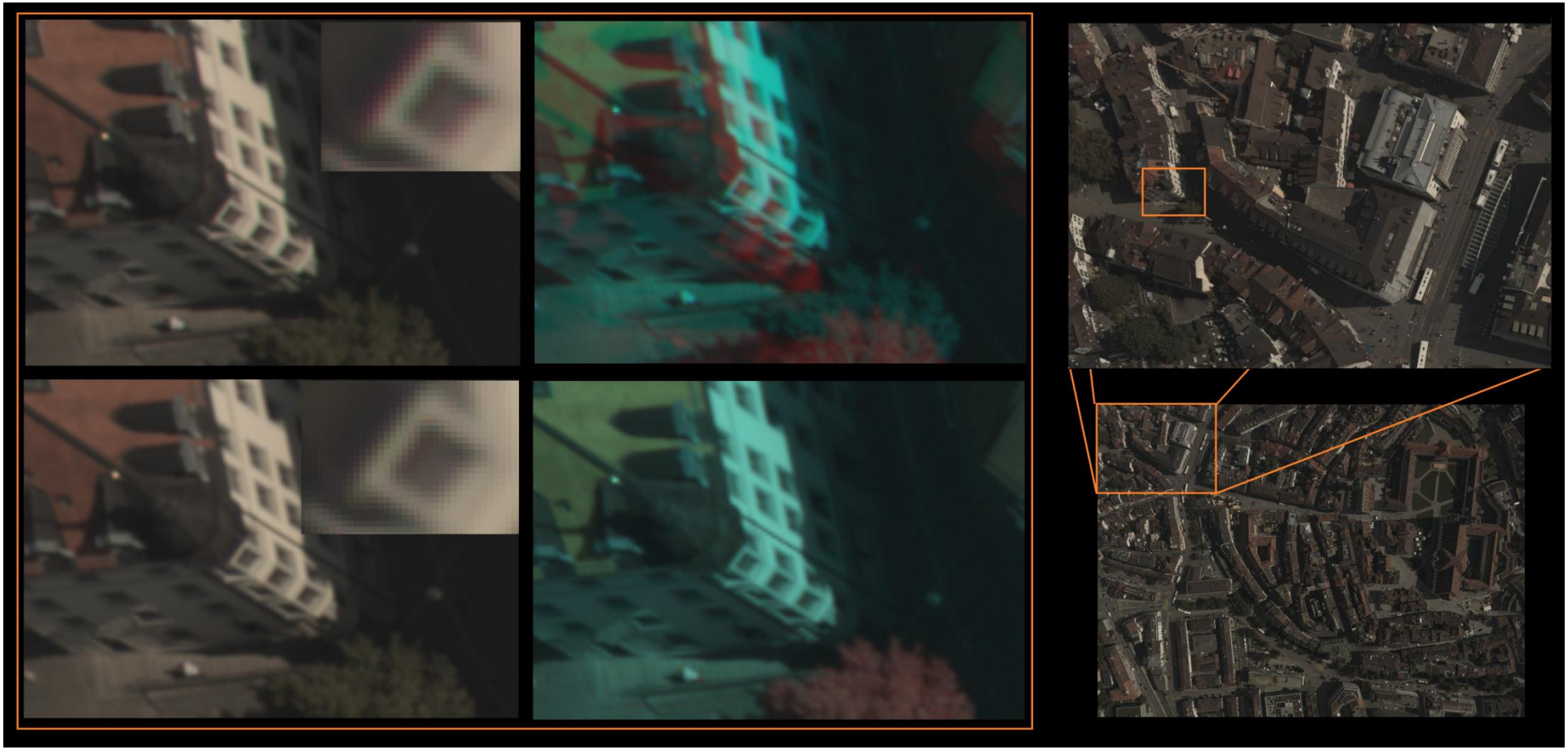
The power to see

ZI IMAGING

- when it has to be right

Leica Geosystems

Coregistration



The power to see ZI IMAGING - when it has to be right Leica Geosystems

Goniometry at Leica Geosystems

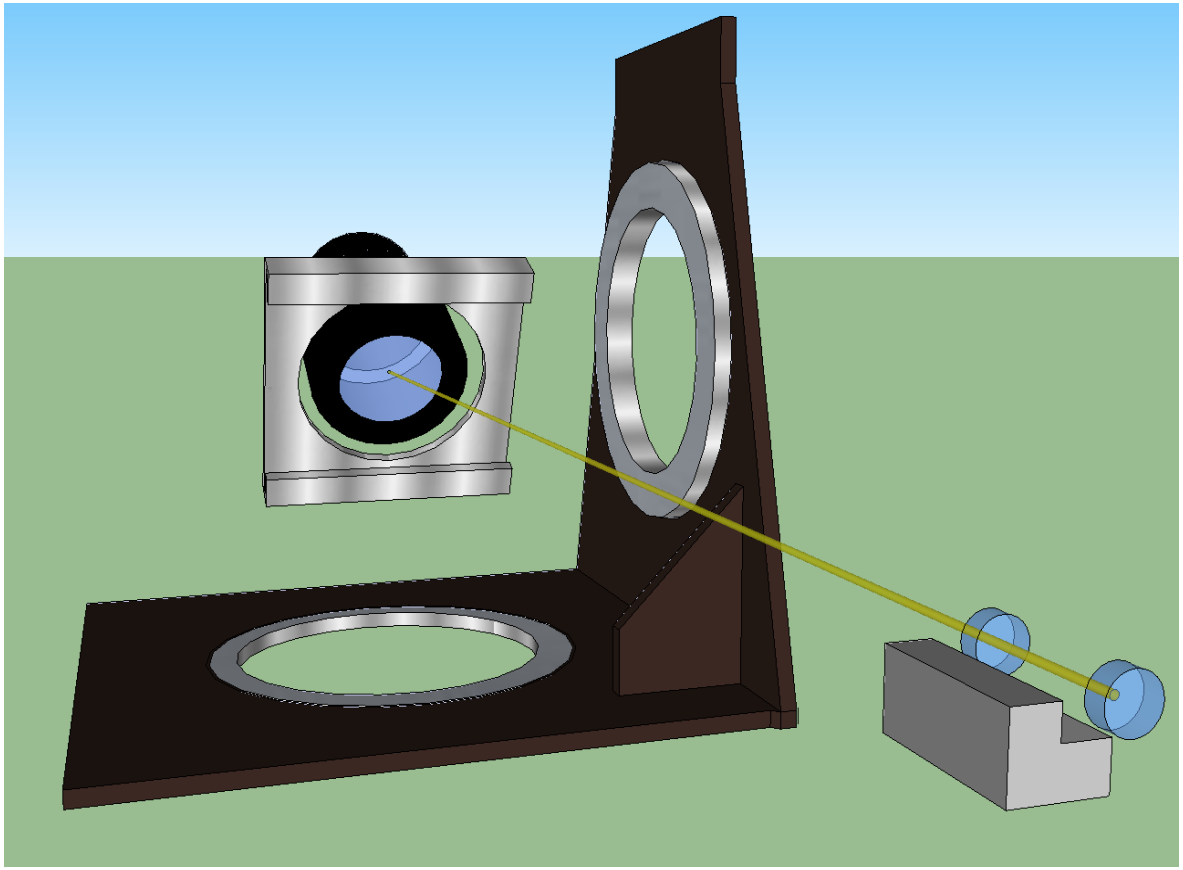
- T4 used for the RC20 calibration.
- * Design based on a high precision single axis
- * Not optimal for heavy lens systems

- Electronic Vertical Goniometer (EVG) used for the RC30 calibration
- * Also based on a High precision single axis but oriented vertically
- * Limited to measurements on the diagonal
- * Not usable for sensors with fixed focal plate (ADS40)

- Coded Vertical Goniometer (CVG) used for the ADS40 calibration
- * Dual axis EVG with fish bone oriented code bars
- * IR transmission performances and stability issues
- * Limited accuracy to 3 pixels

RCD30 Goniometer design

- Numerically controlled precision rotation stages (absolute error ±10")
- Allow measurements in the direct and reverse positions
- Collimator used to project pinhole to infinity
- Autocollimation mode for infinity adjustment
- Mount for camera RCD30, RCD105
- Precise polygon mirror for goniometer calibration
- Temperature controlled room



The power to see ZI IMAGING - when it has to be right Leica Geosystems

RCD30 Goniometric calibration workflow

Measurement of the principal point position with an equidistant cross

↓

Measurement at equidistant object positions

↓

Computation of the distortions and interpolation to an equidistant grid in the image plane

↓

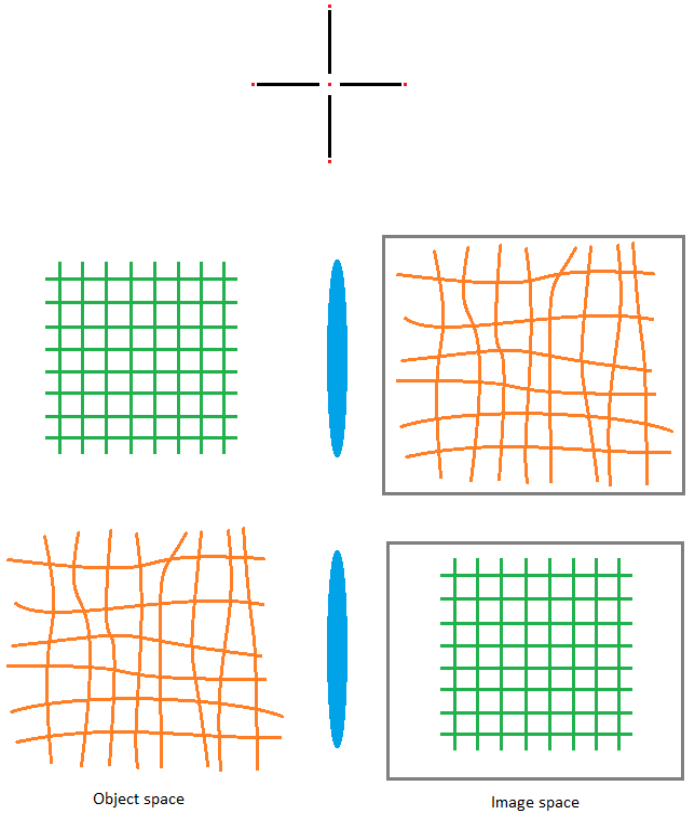
Repeating the measurements at equidistant image positions using the interpolated distortions

↓

Computation of the distortions and interpolation to an equidistant grid in the image plane

↓

Image rectification with Leica FramePro and final check

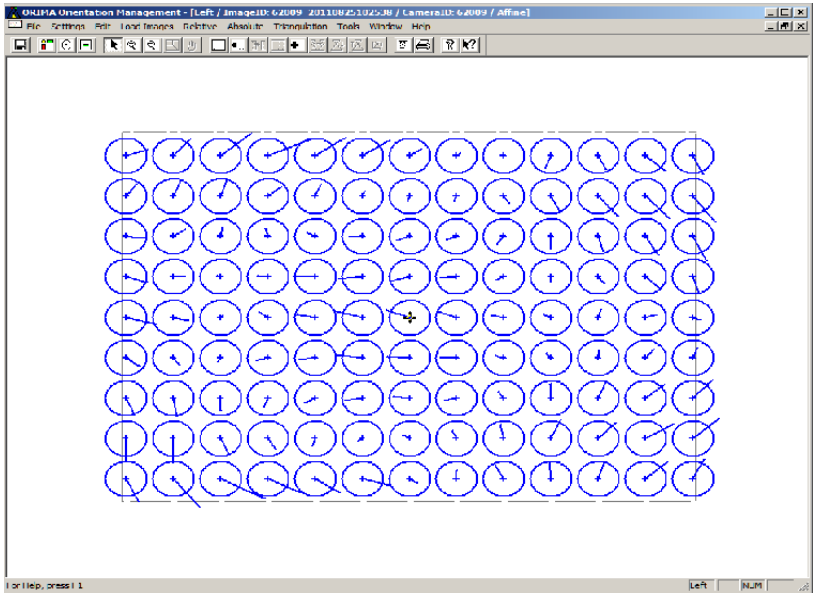


Comparing the approaches

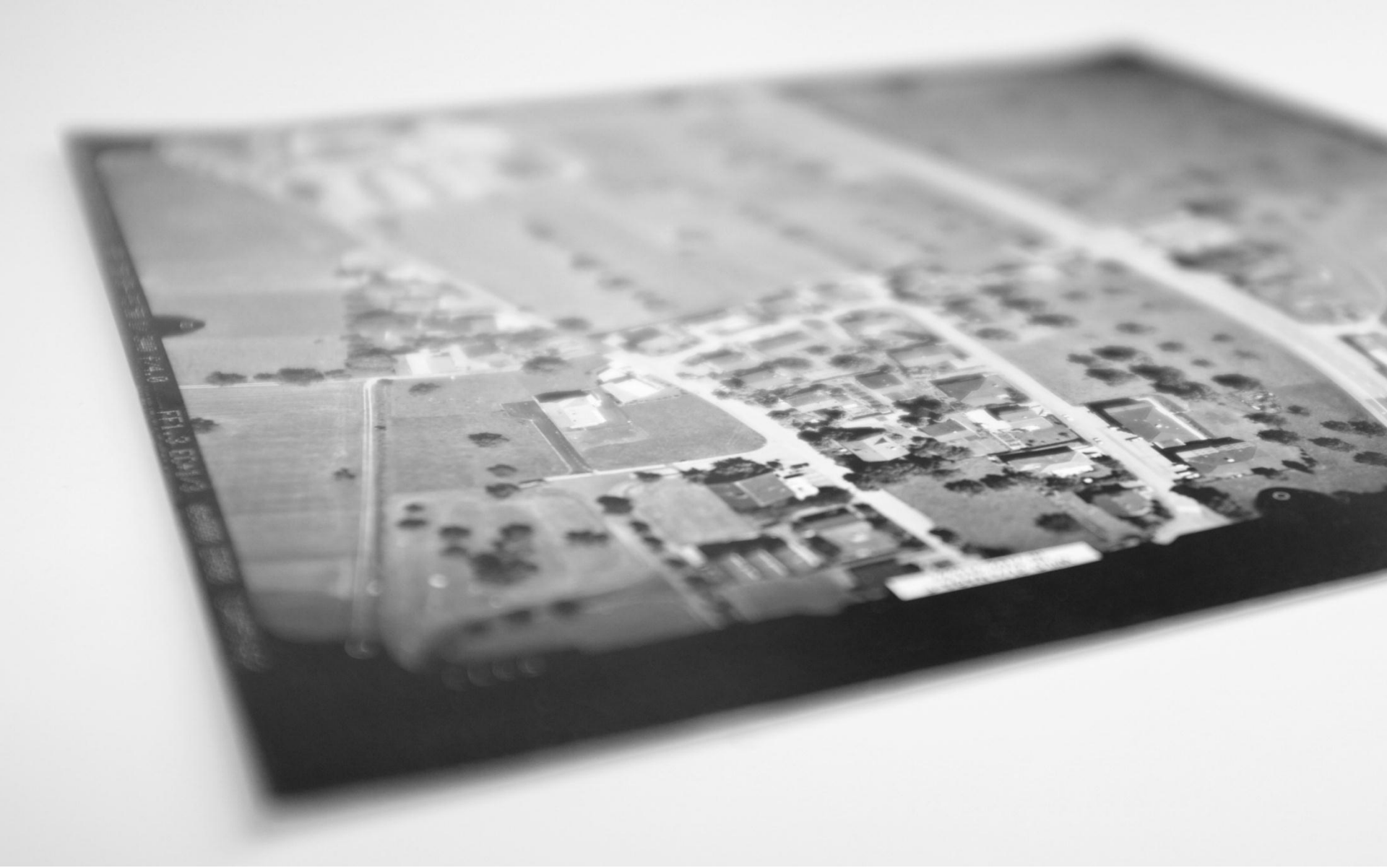
- Goniometry
- * independent from weather conditions
- * automatic procedure, reduced costs

- Flight
- * no need to ship a camera
- * IMU misalignment estimation

- Similar quality, comparisons still show effects in 1/3 pixel range.
- → Get better understanding of it.



The power to see - when it has to be right



Thank you!

The power to see ZI IMAGING - when it has to be right Leica Geosystems