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Calibration Issues in High Accuracy Mobile Mapping

Jens Kremer

EuroCOW 2012

12.02.2012, Castelldefels, Spain

IGI mbH

www.igi-systems.com

- Founded 1978
- 25 staff – about half in R&D
- More than 380 customers in 60 different countries
- World-wide technical support

IGI office in Kreuztal

IGIs Modular Sensor Systems

www.igi-systems.com

- Missionplanning
- Navigation
- GNSS/IMU
- Sensor Management

IGIs Mobile LiDAR Solutions

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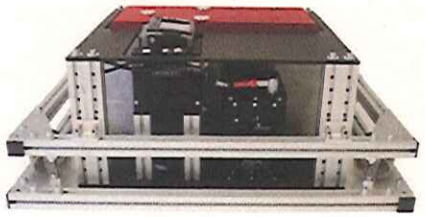
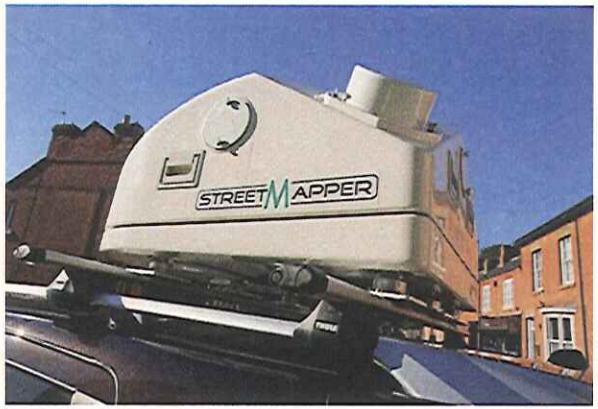
LITEMAPPER®



STREETMAPPER®



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Mobile LiDAR Mapping

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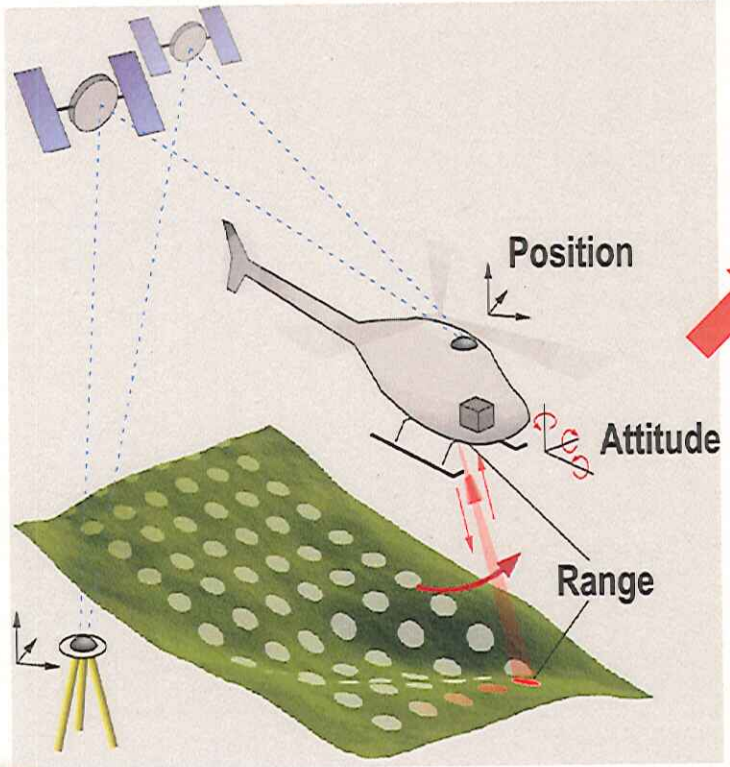
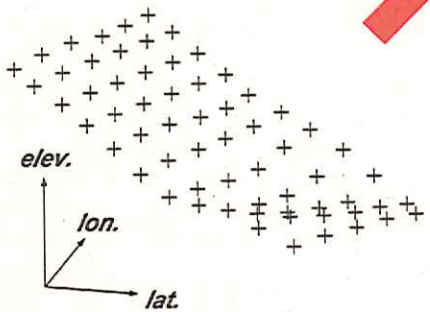
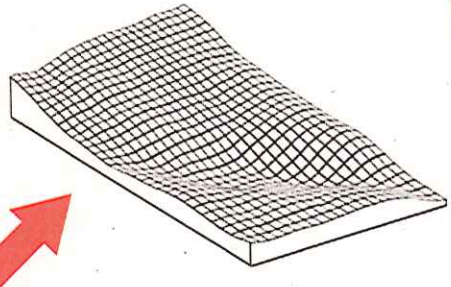




Georeferenced pointcloud

DSM



Georeferencing Workflow

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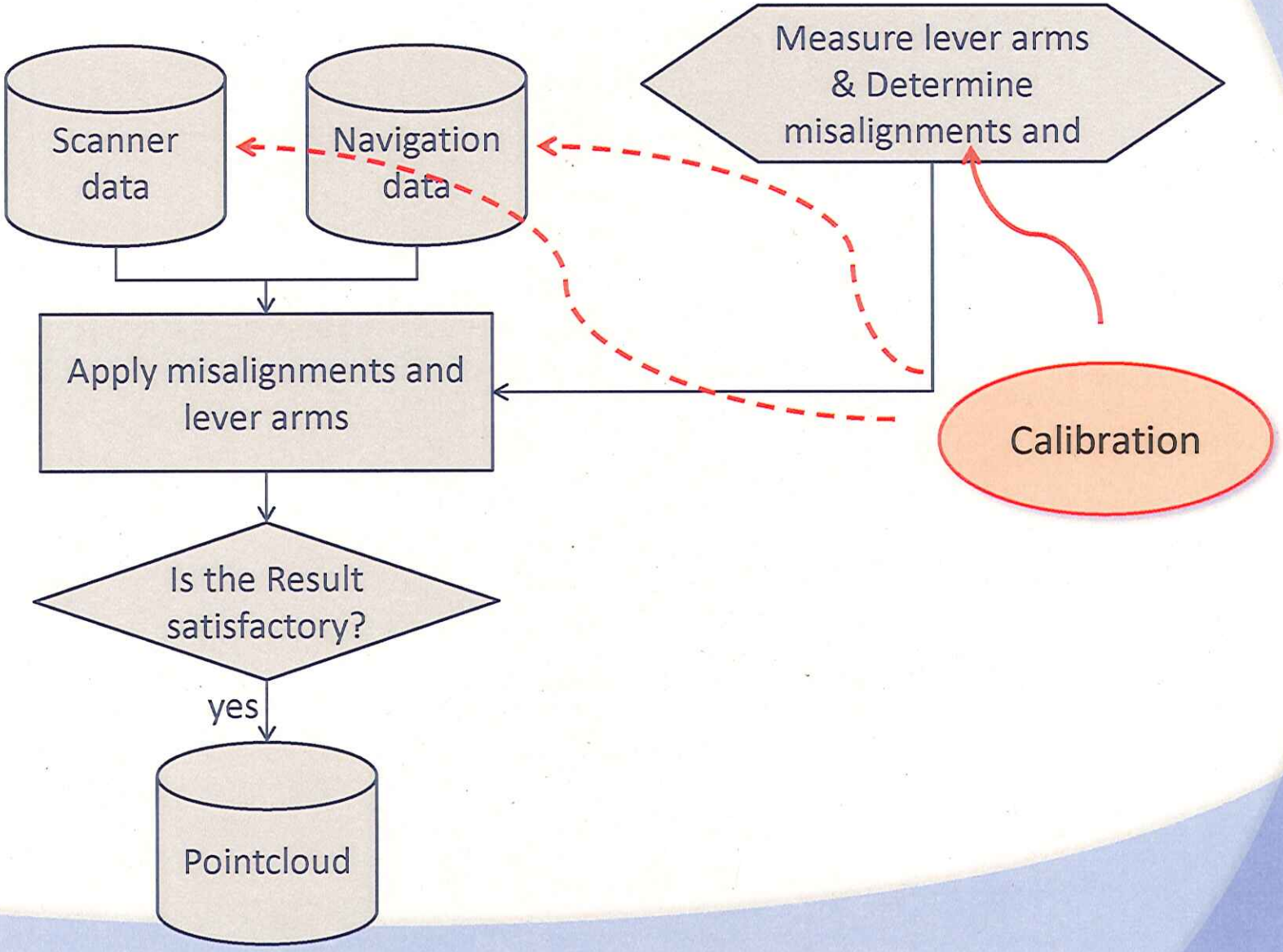

Calibration Airborne I

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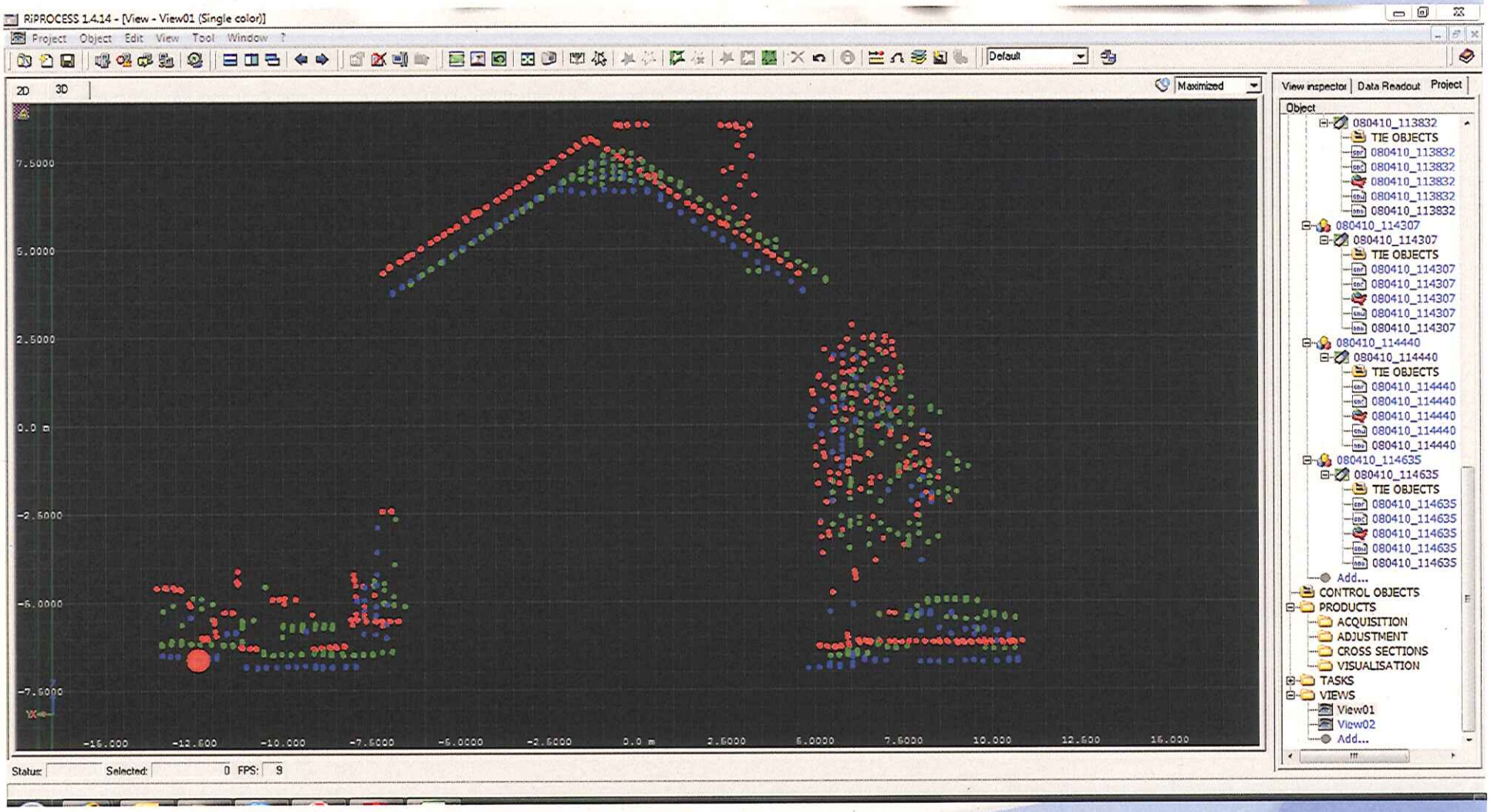

Calibration Airborne II

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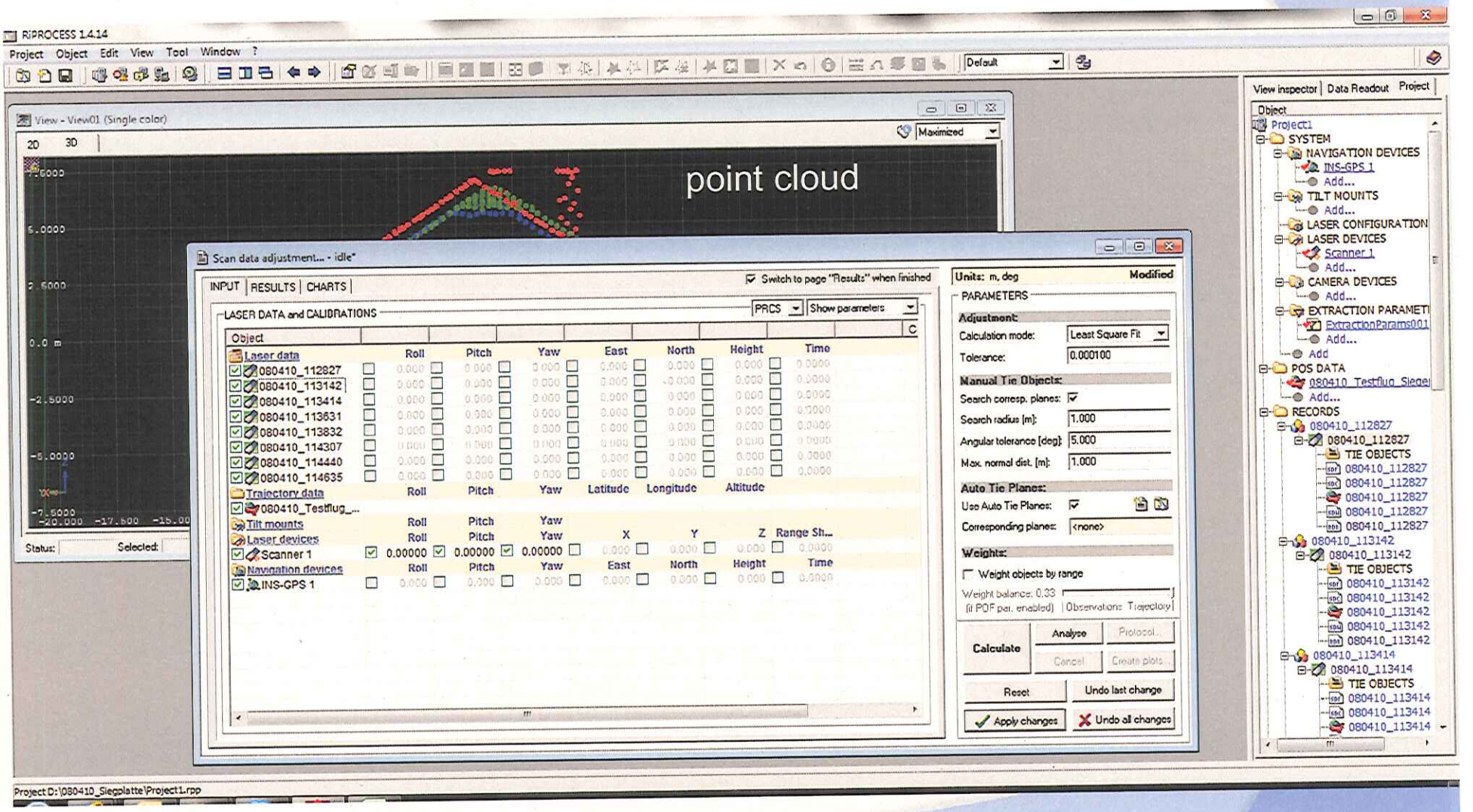

Calibration Airborne III

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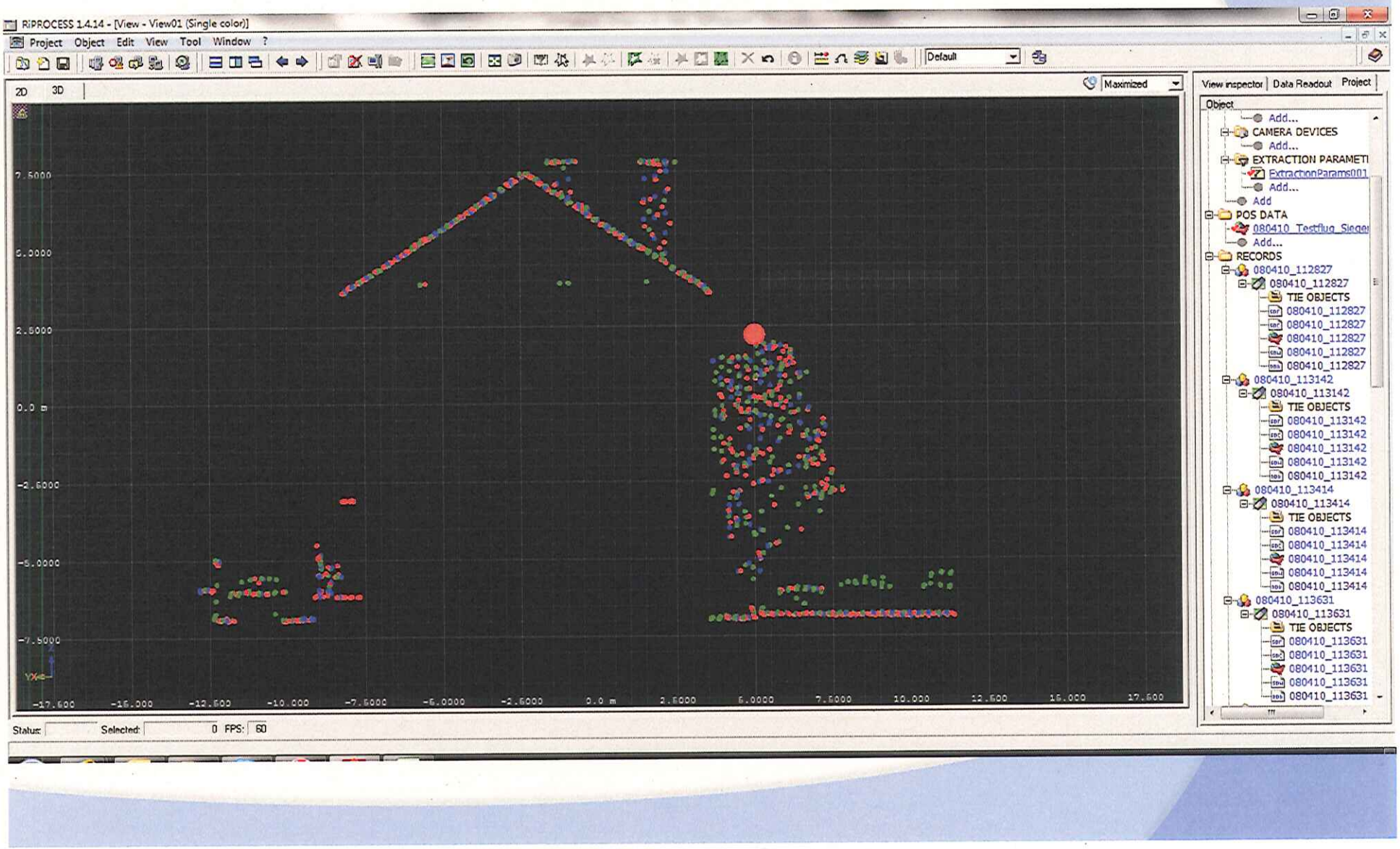

Calibration Mobile

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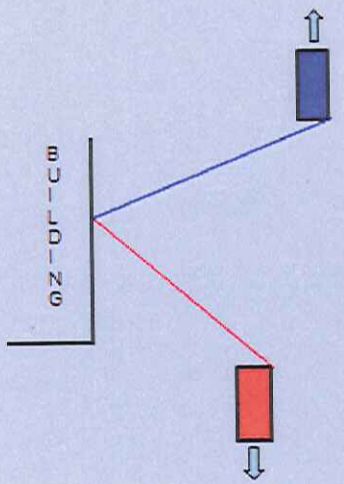
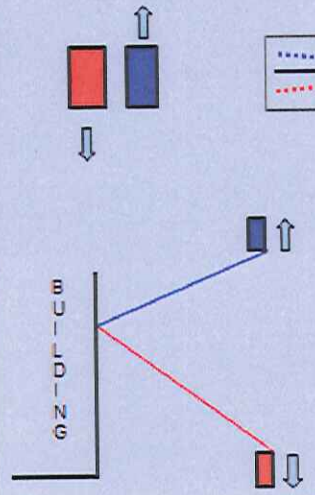
Heading error

- Mismatch visible only at longer distance from scanner
- Mismatch visible in walls -- solvable only with right pattern
- Mismatch visible in point features (poles, building corners)



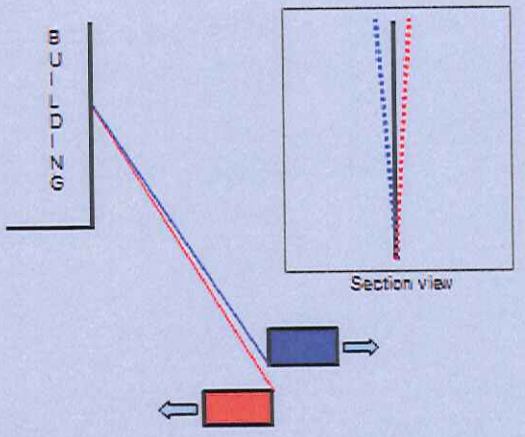
Roll error

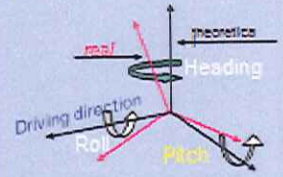
- Mismatch visible only at longer distance from scanner
- Mismatch visible as elevation difference in ground
- Mismatch visible as leaning building walls



Pitch error

- Mismatch visible only at longer distance from scanner
- Mismatch visible as elevation difference in ground
- Mismatch visible as leaning building walls





Terrasolid

Calibration driving pattern I

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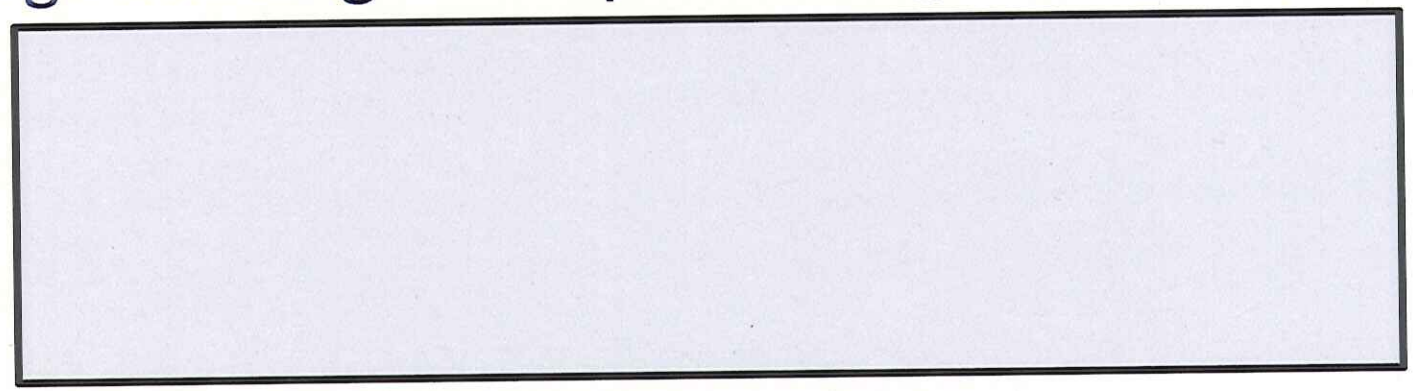
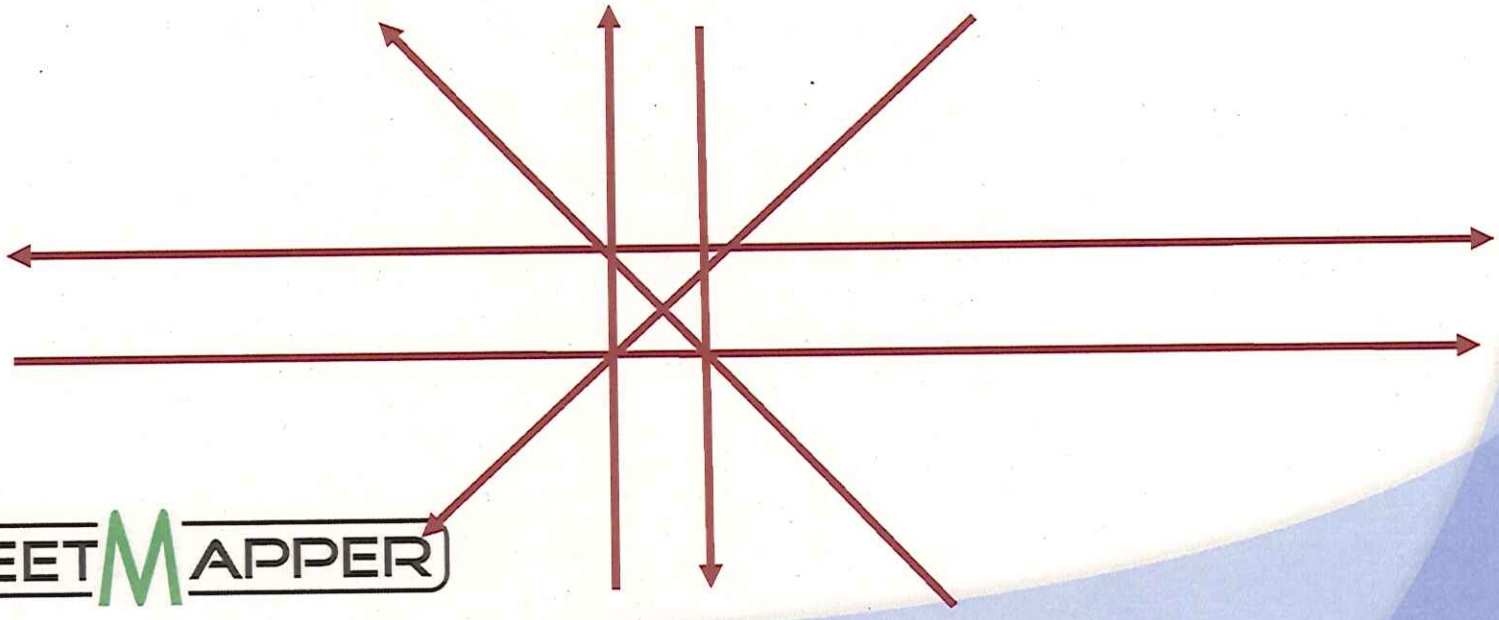
- Large building with open area (parking lot)





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Calibration driving pattern II

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IGI engineers installing a RailMapper calibration field …

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Georeferencing Workflow

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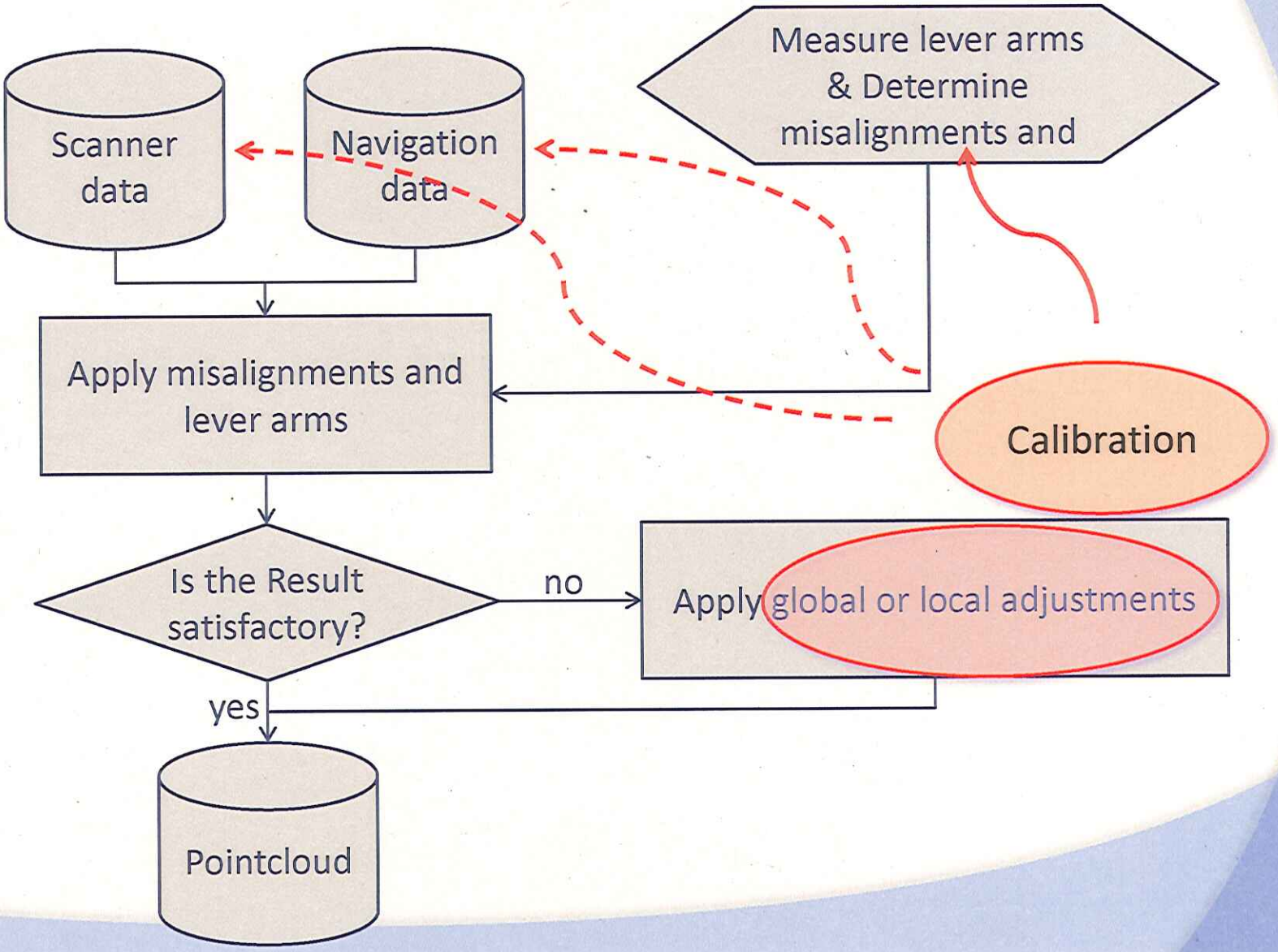

Airborne Lidar & "Mobile Mapping"

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Same sensor technologies

- LiDAR, GNSS/INS, different cameras

Similar calibration and orientation strategies

Differences:

- Distance to the object
- GNSS conditions
- Kinematic conditions

Navigation - Standstill

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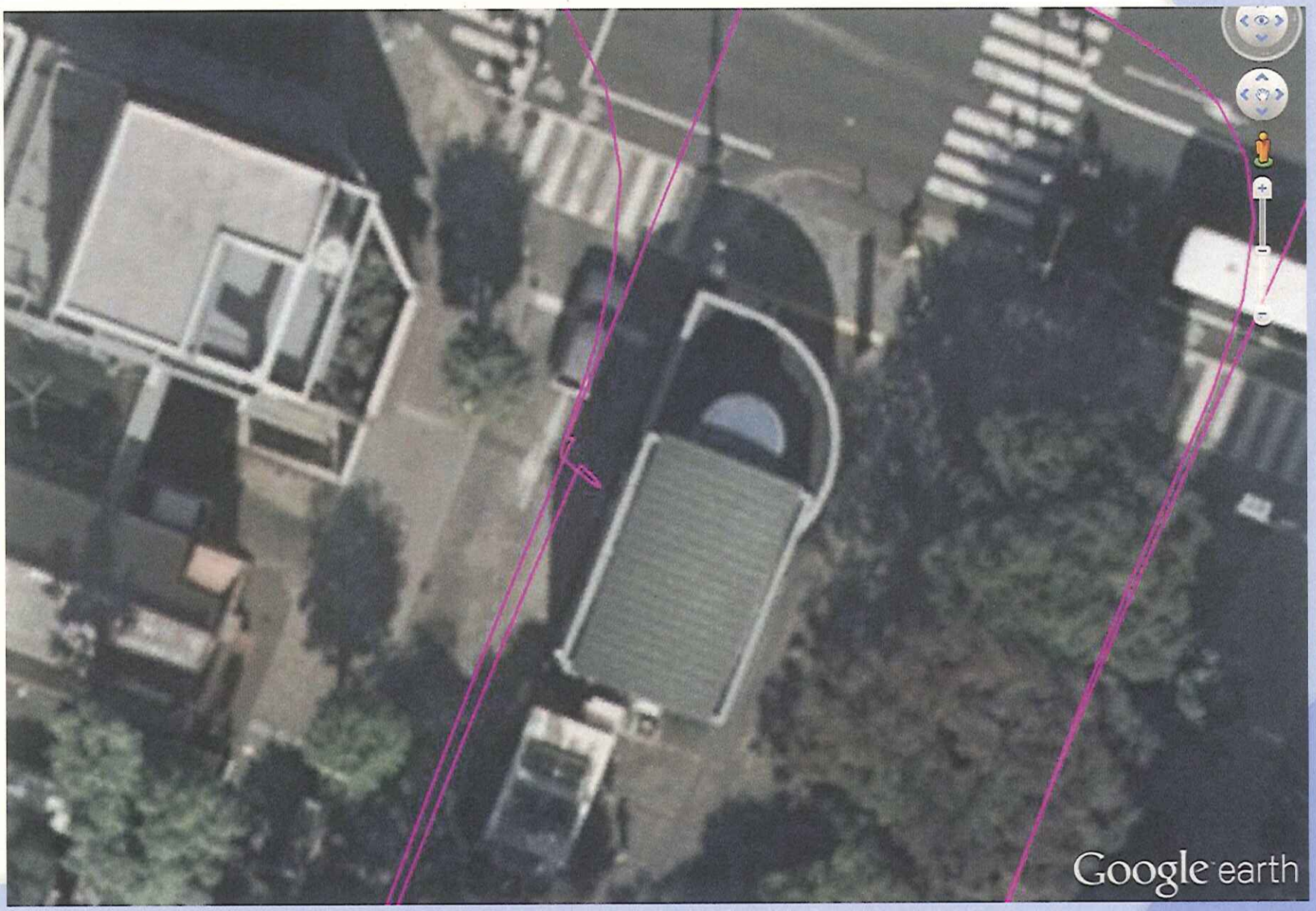

GNSS: Air vs. Ground

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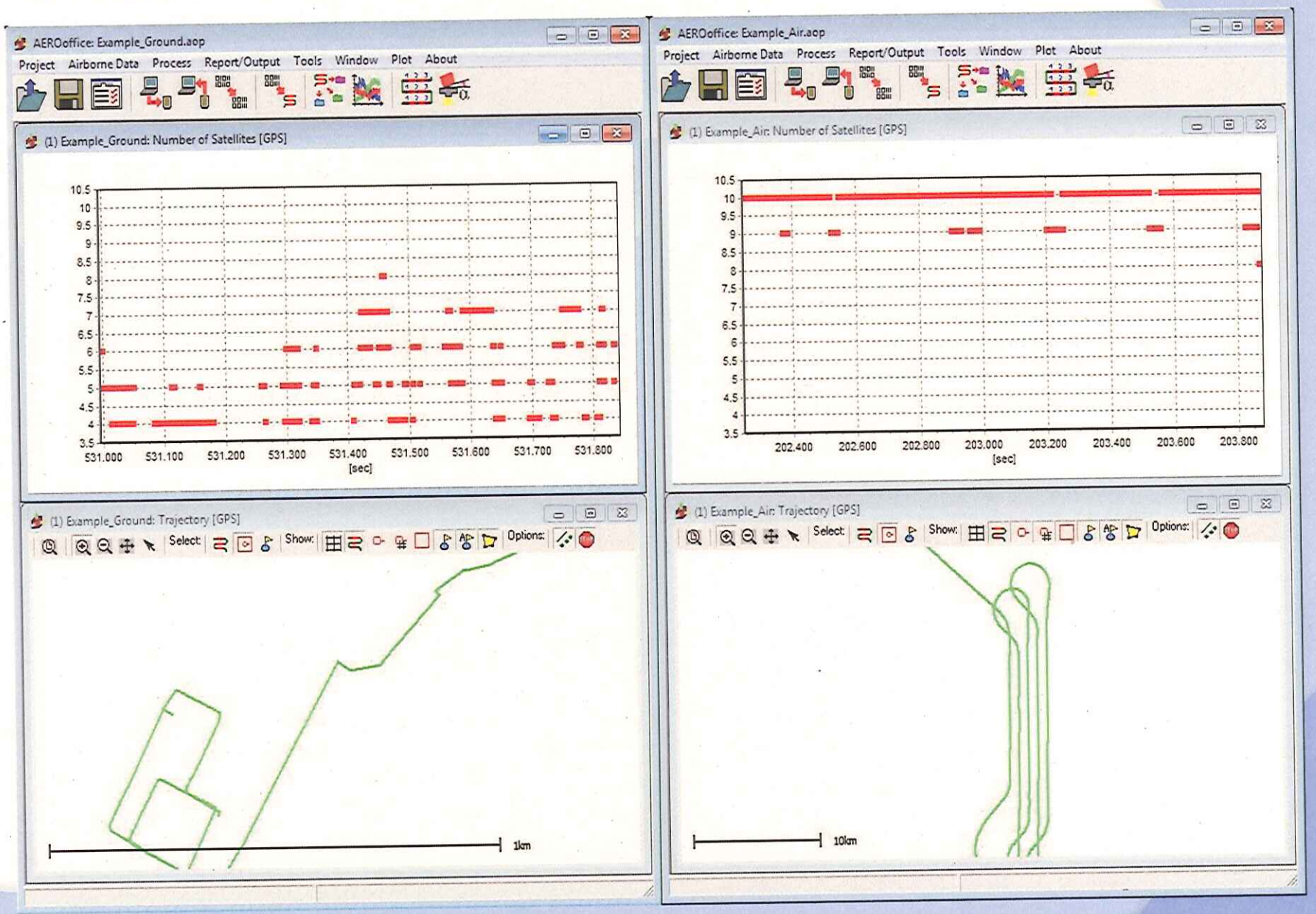

Measurement Geometry

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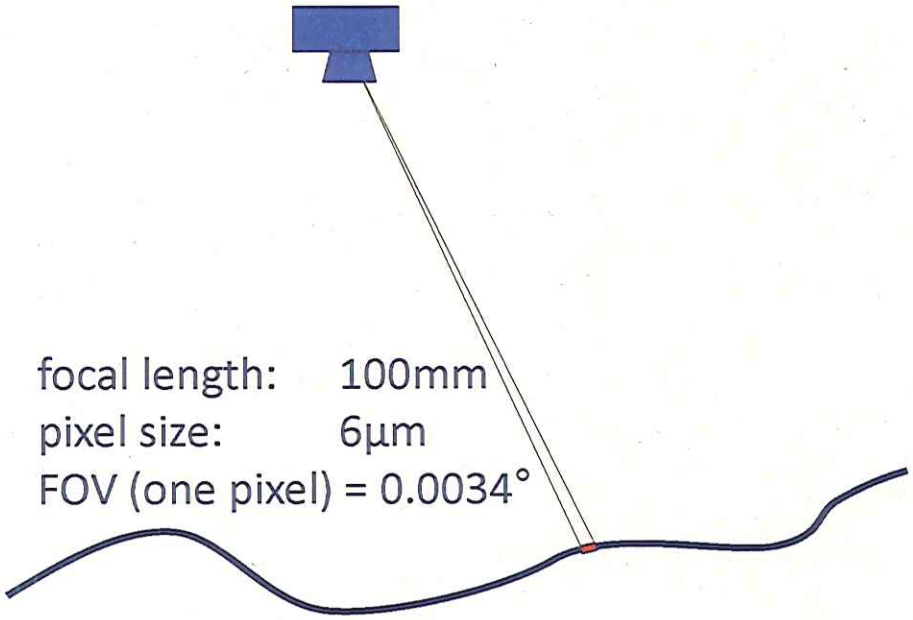
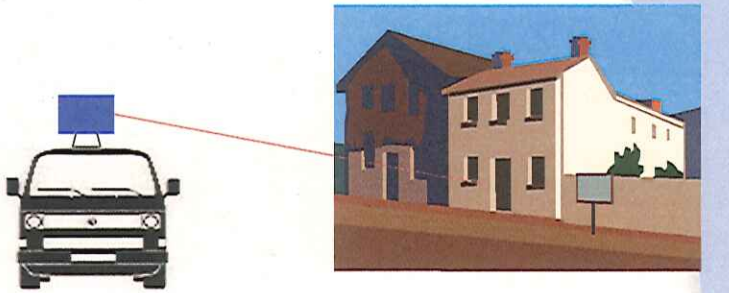
Airborne LiDAR / Photogrammetry



focal length: 100mm
pixel size: 6µm
FOV (one pixel) = 0.0034°

LiDAR Mobile Mapping



distance: 5m
accuracy: ~1cm
angular error = 0.1°

Application	Position	Orientation
Airborne LiDAR or Airborne Photogrammetry	cm – dm	0.01° – 0.001°
Airborne Thermography	dm	0.1° – 0.01°
LiDAR Mobile Mapping	mm – cm	0.1°

Georeferencing Workflow

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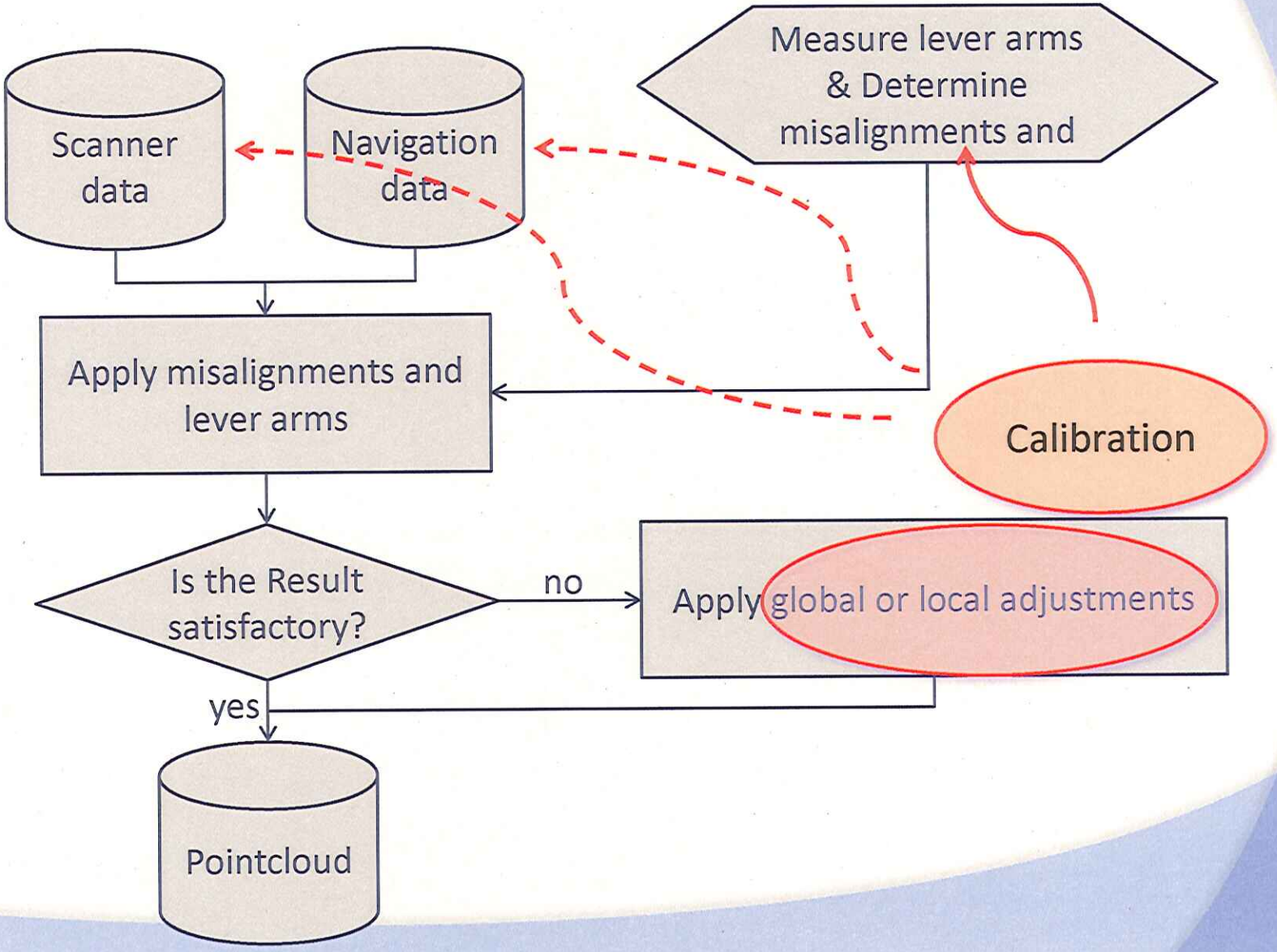

Adjustment

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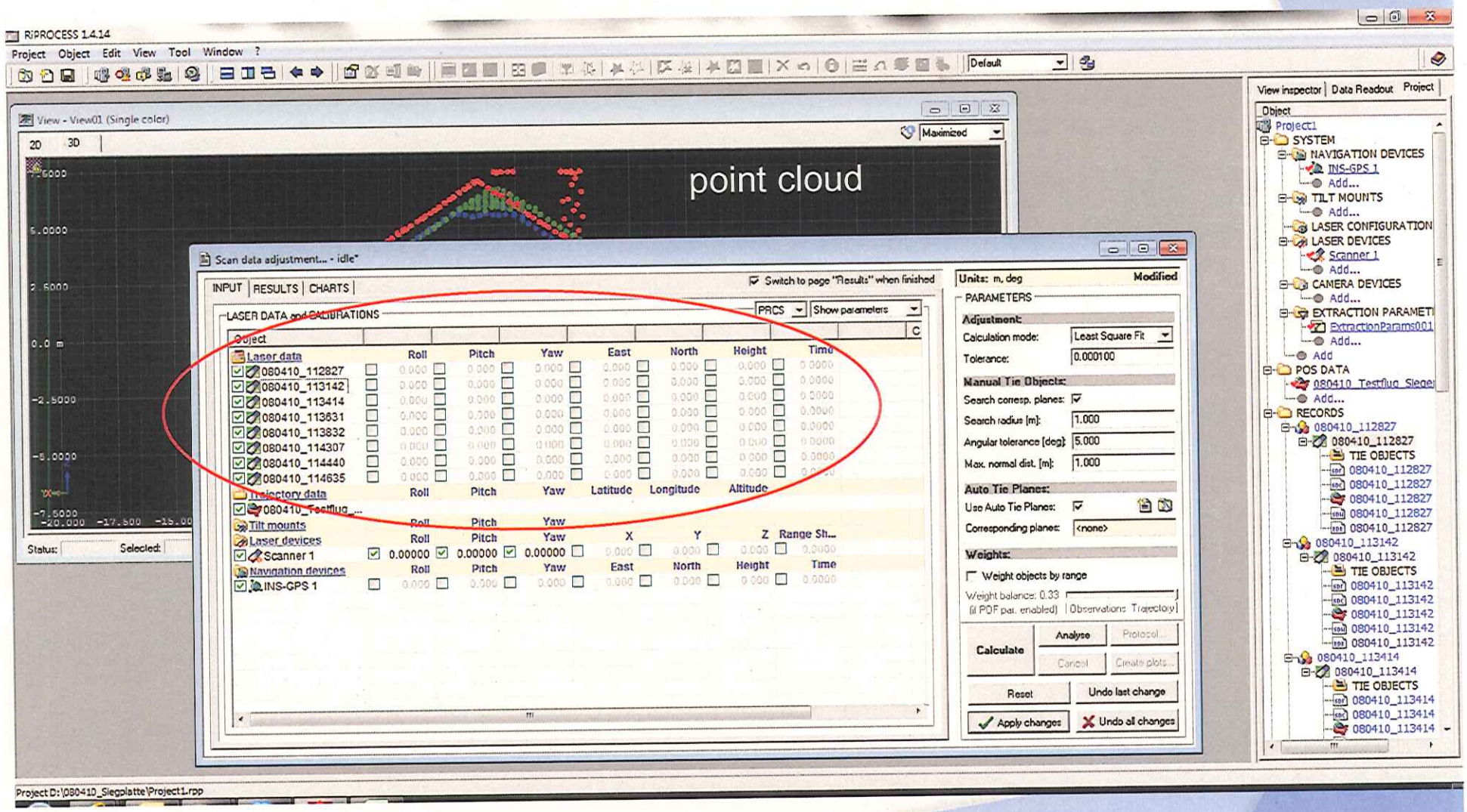

Terrasolid – Tie Lines

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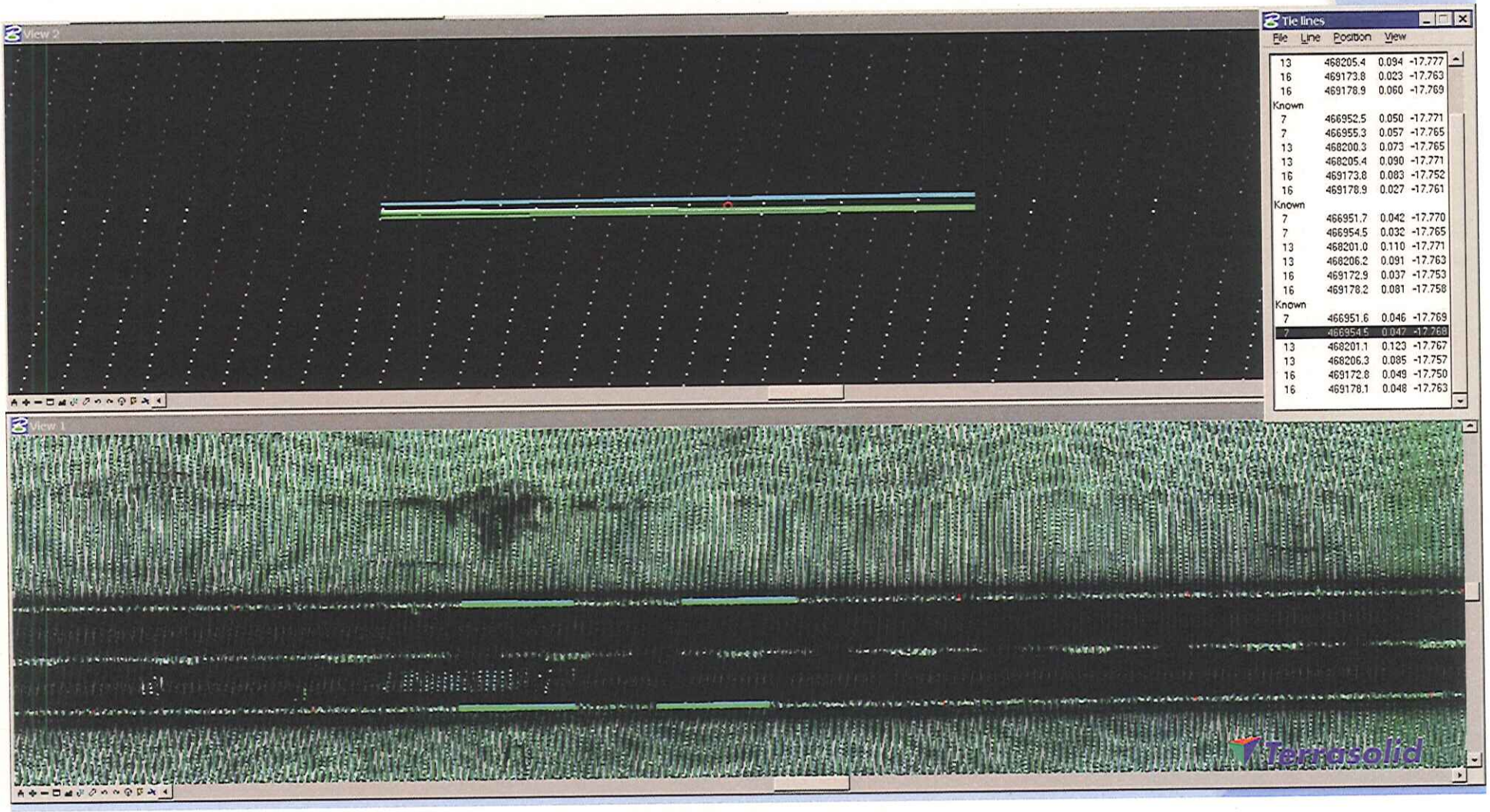
Matching based on intensity or xyz features in LIDAR

Matching based on linear features in images



Geometric Correction

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Typical control points

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GPS vs. GPS & GLONASS

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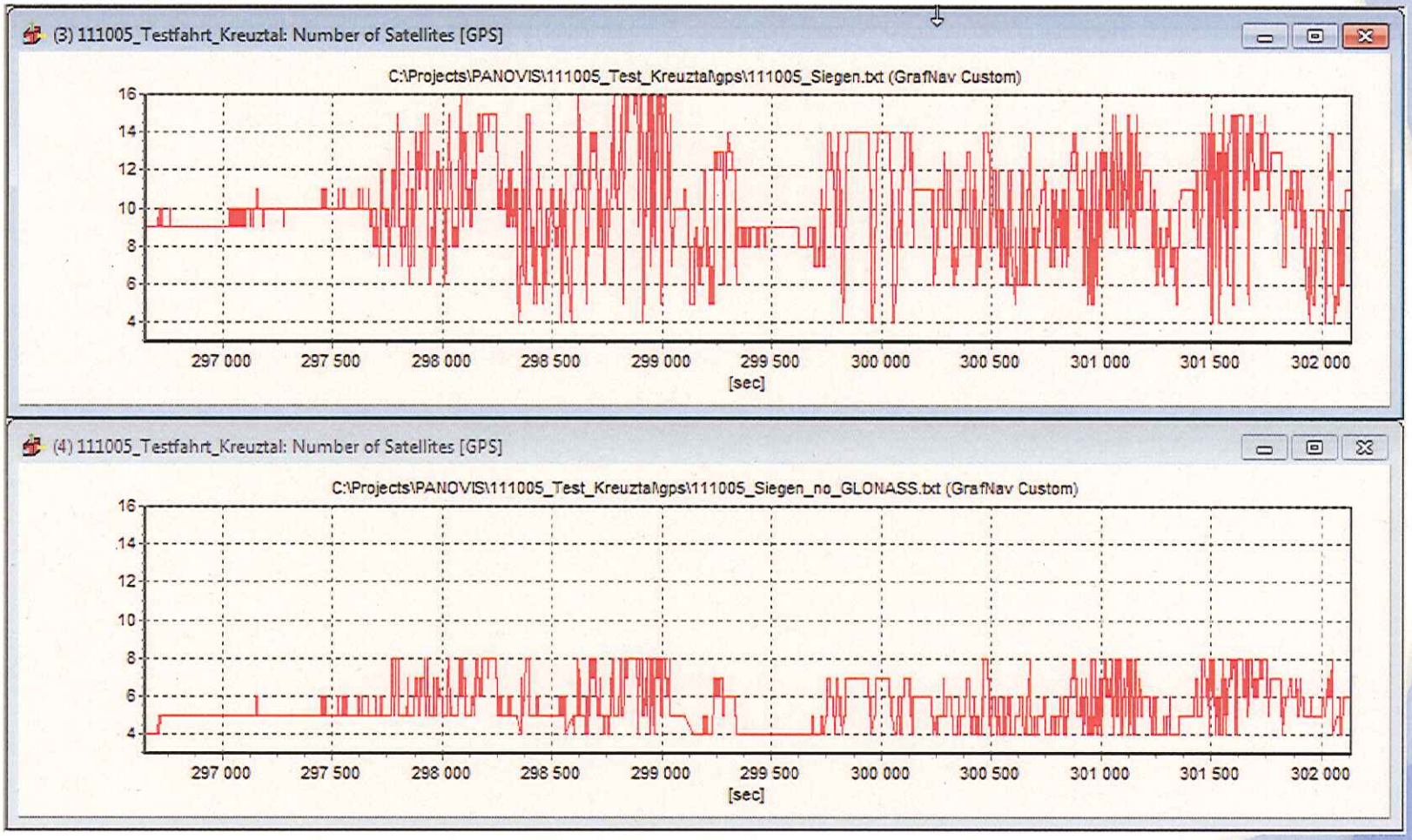

GPS vs. GPS & GLONASS

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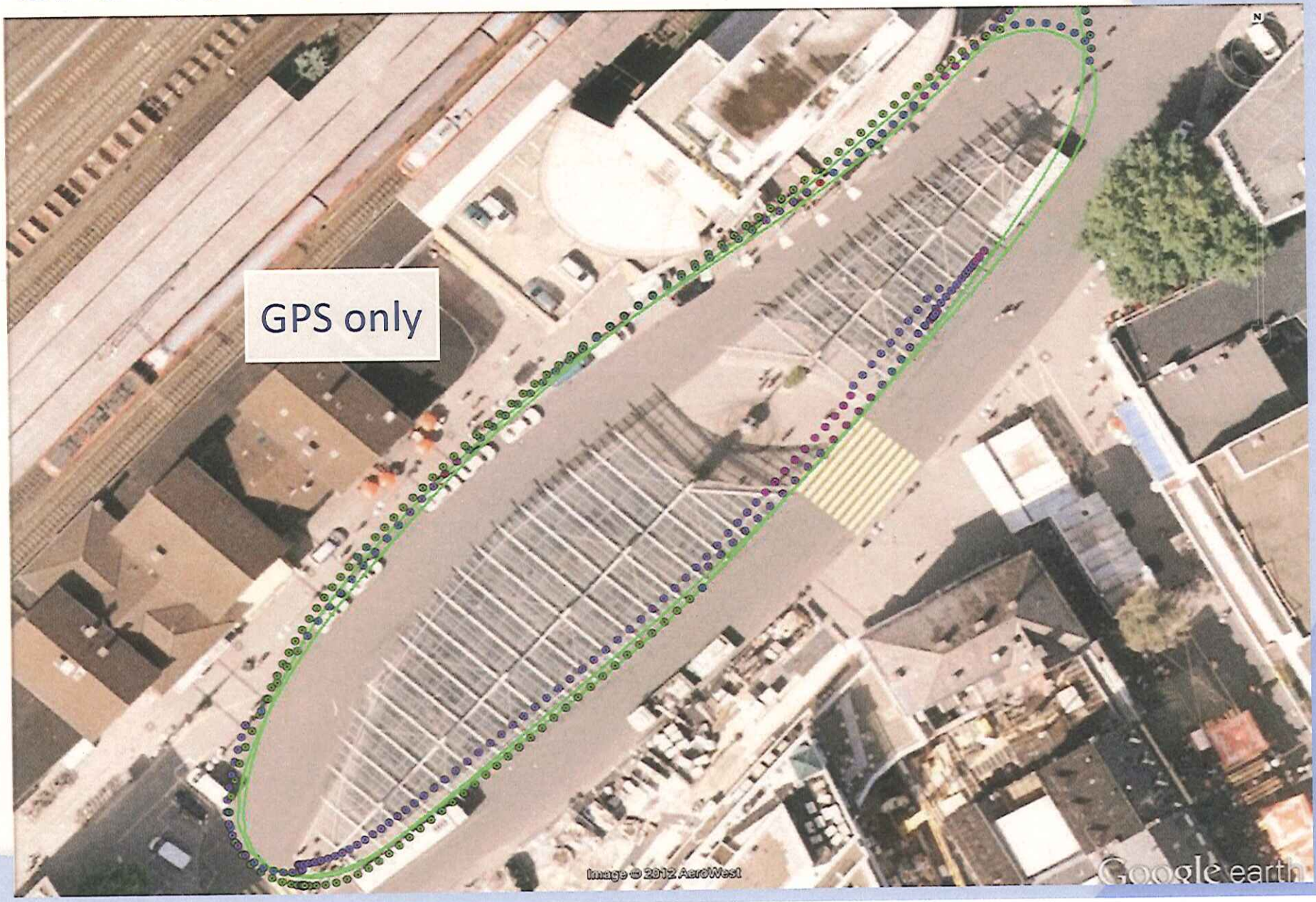

GPS vs. GPS & GLONASS

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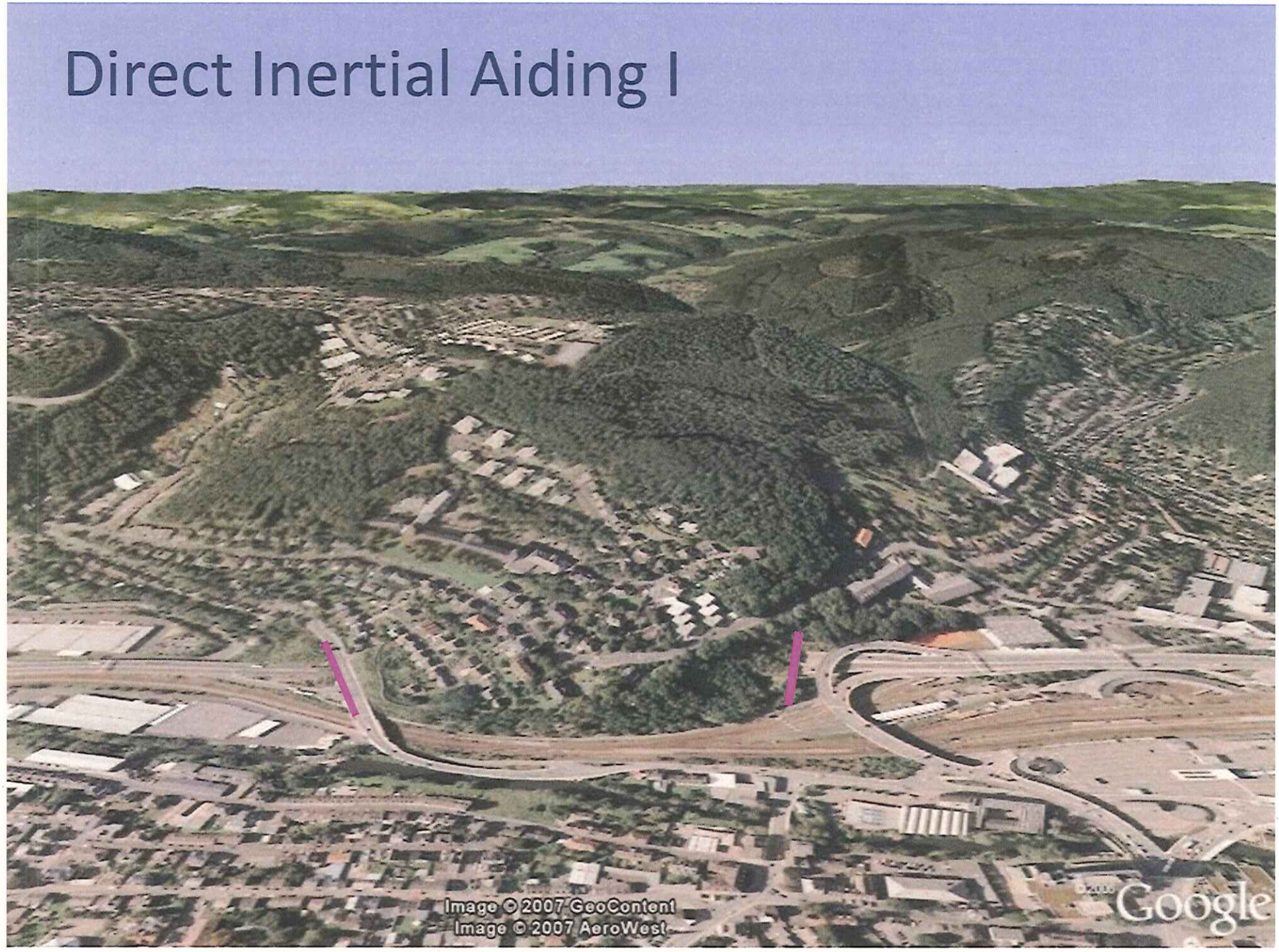
Direct Inertial Aiding I



Direct Inertial Aiding II

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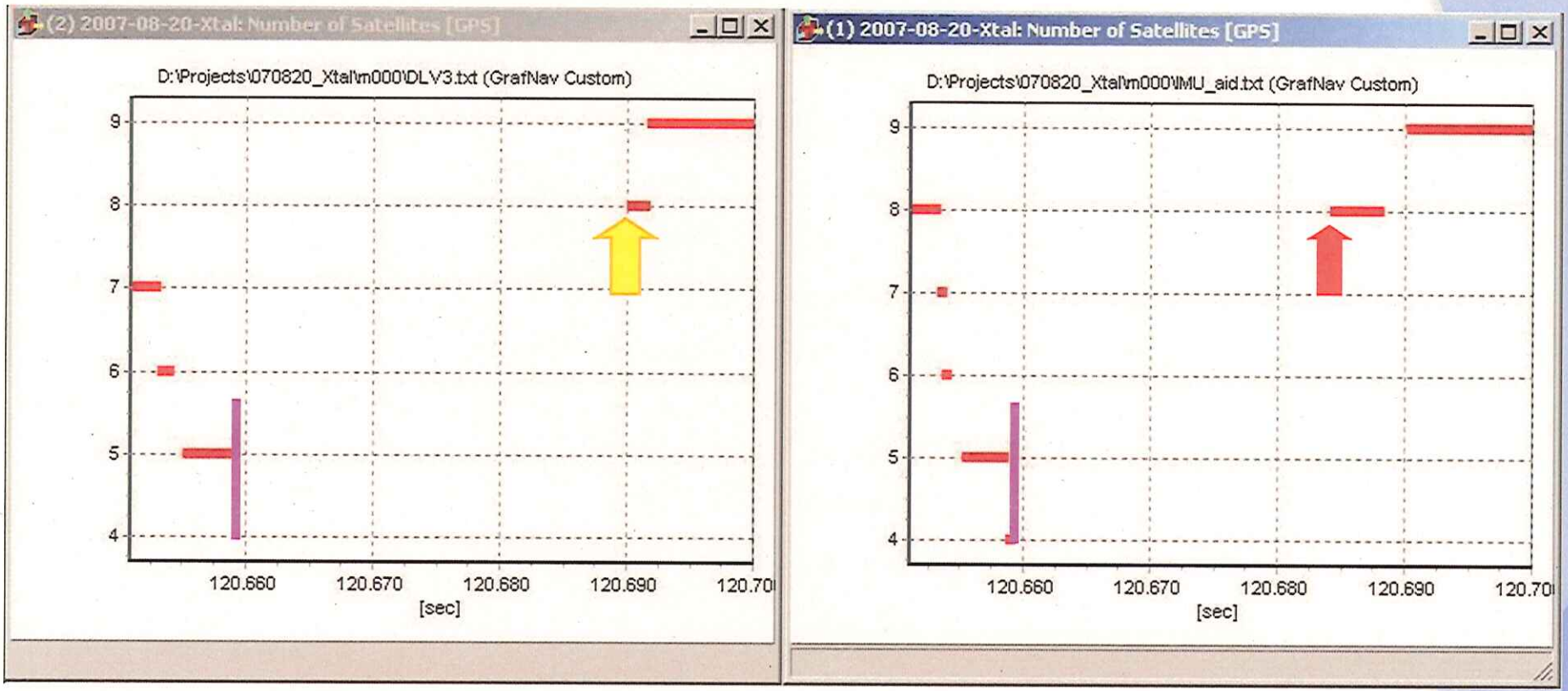
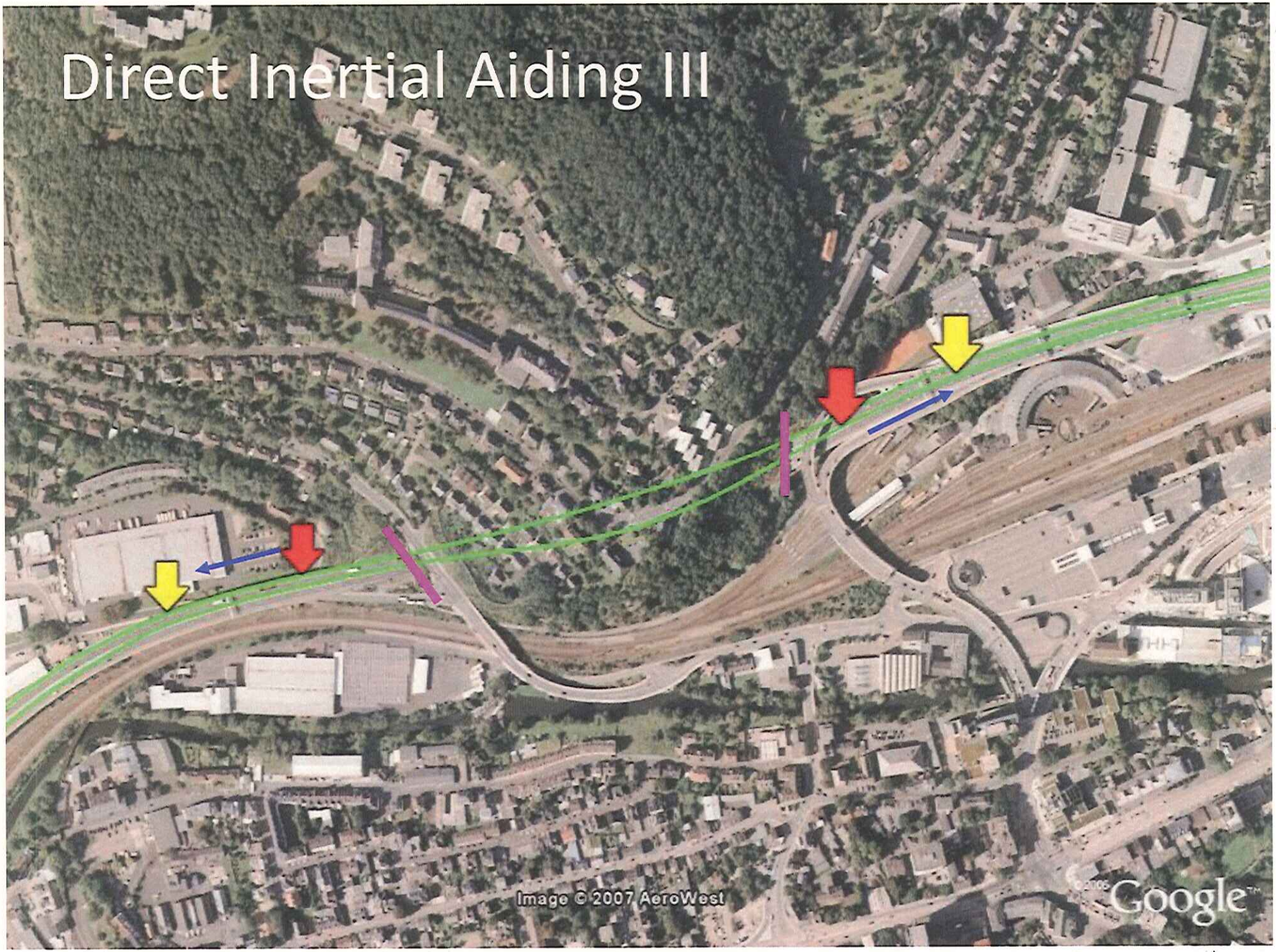


Direct Inertial Aiding III



Navigation – ZUPT

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Navigation – ZUPT

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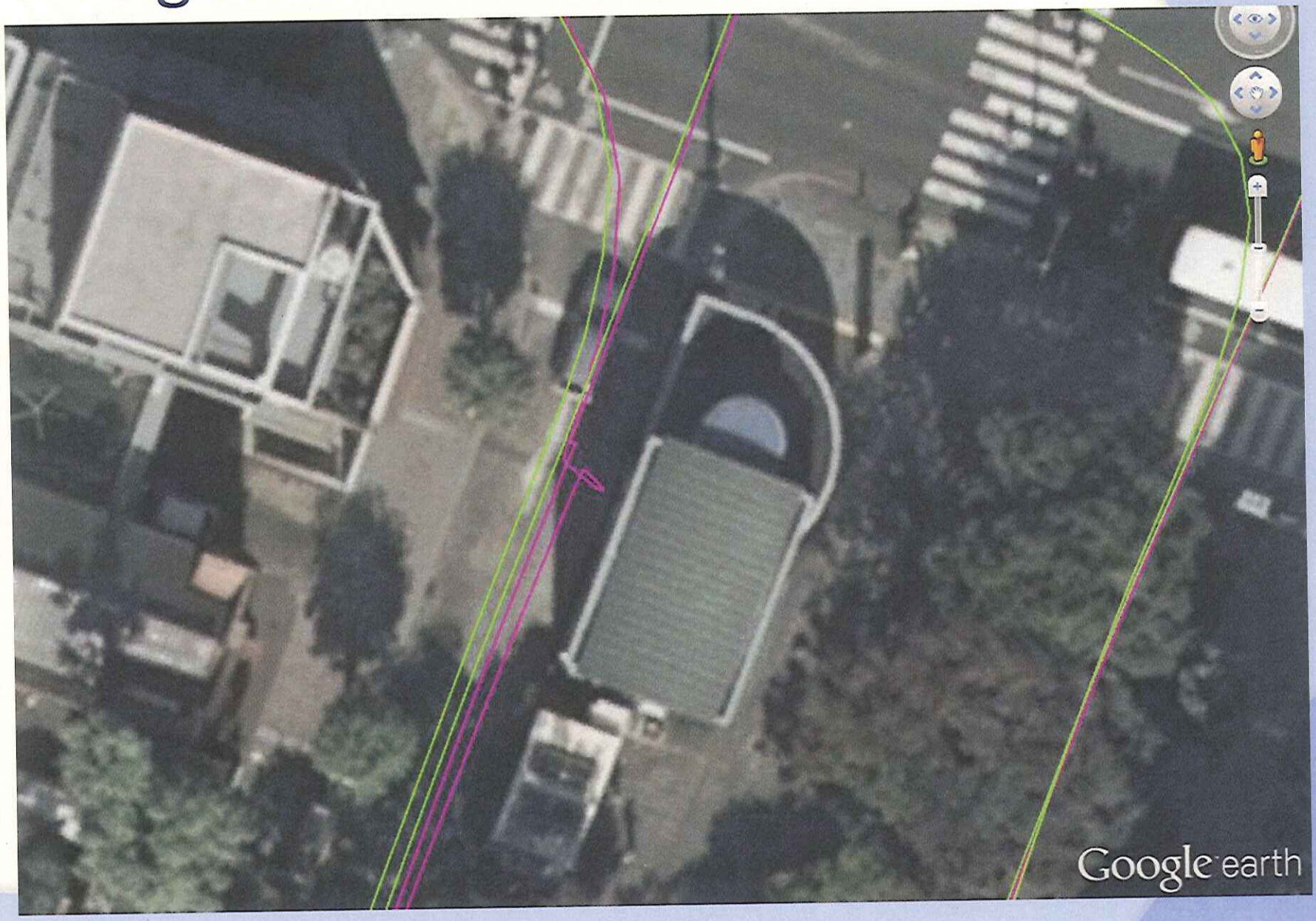

IMU Performance

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IMU Performance

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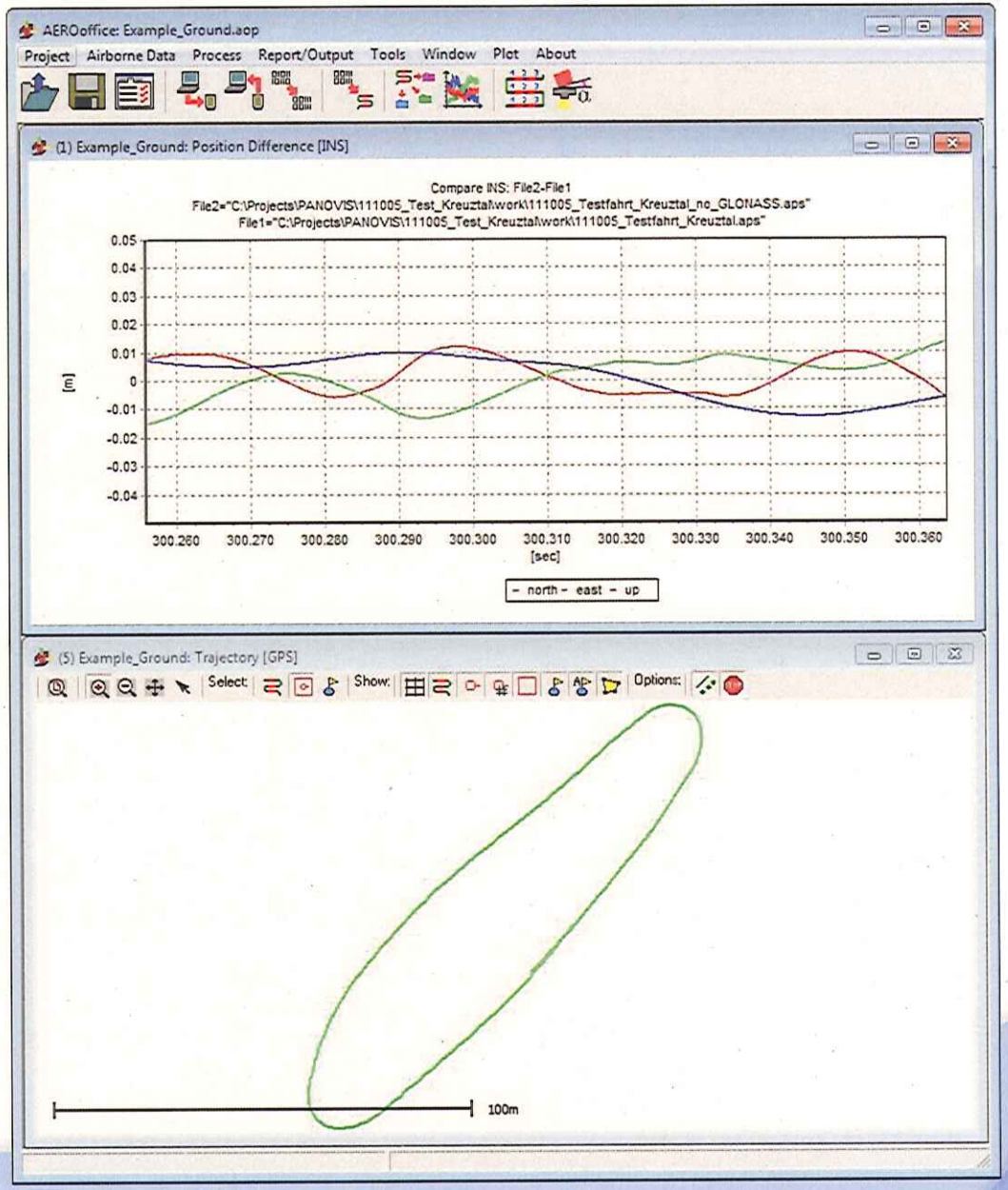
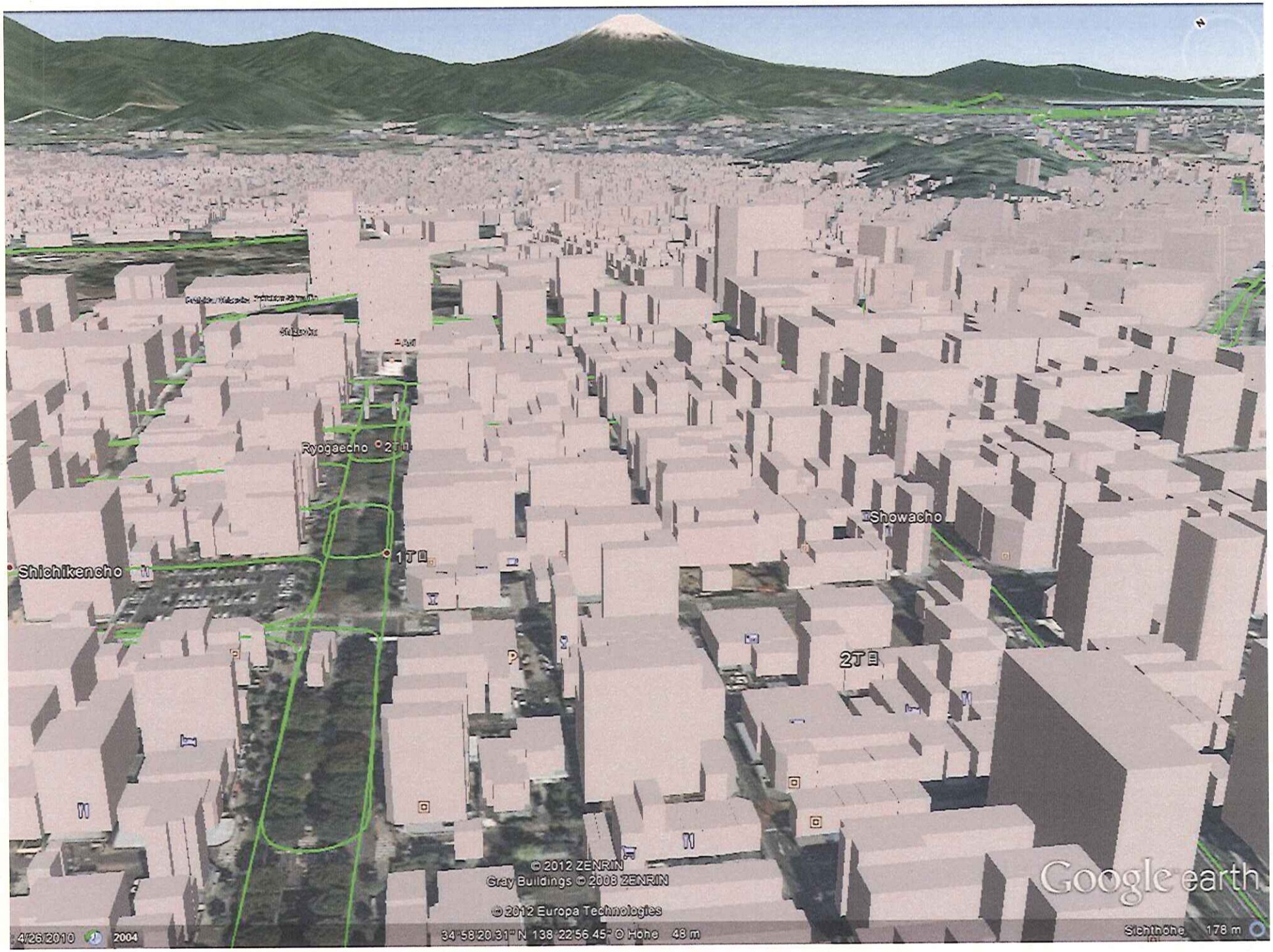
INS solution based on GPS only compared to GPS/GLONASS




Ryogaecho
Shichikencho
Showacho
1丁目
2丁目
© 2012 ZENRIN
Gray Buildings © 2008 ZENRIN
© 2012 Europa Technologies
4/26/2010
2004
34°58'20.31" N 138°22'56.45" O Höhe 48 m
Sichthöhe 178 m
Google earth

STREETMAPPER Examples

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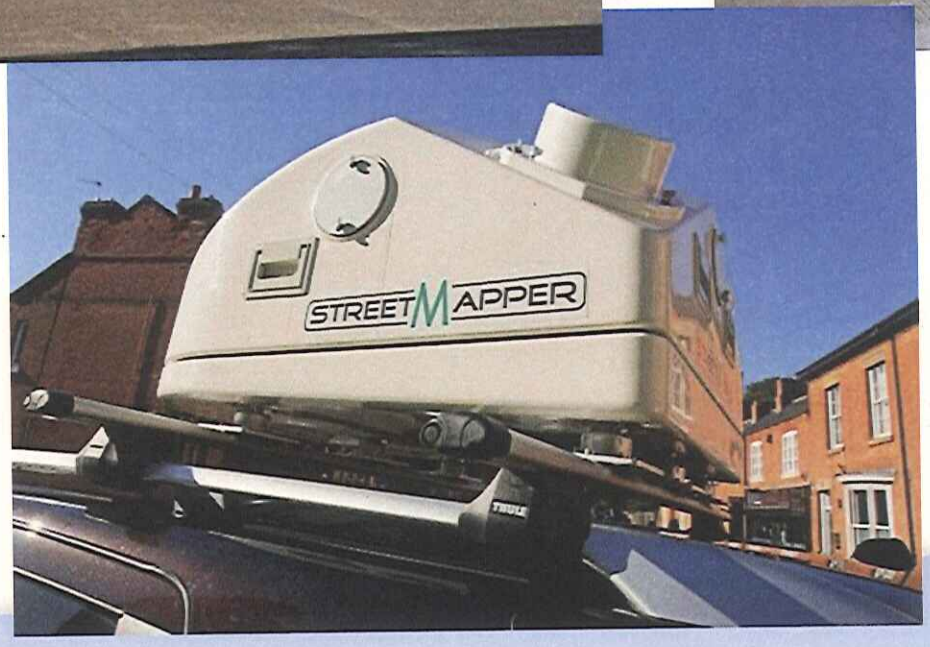


UK Highway M25

- 10 mile survey on highway
- Nearest active base station 8 miles away
- 15 control points used for processing
- 15 control points used by client as a check
- Between 7 and 9 satellites visible
- Drive survey twice
- Check accuracy
- Geometric correction:
  - fit two passes
  - tie lines to adjust data
  - control points to adjust data
- Check accuracy

3D laser mapping

STREETMAPPER

UK Highway M25

Average dz	0.001
Minimum dz	-0.025
Maximum dz	0.026
Average magnitude	0.008
RMS	0.012
Std deviations	0.012

Table 1: Control Points 1 compared with uncorrected data

Average dz	-0.001
Minimum dz	-0.02
Maximum dz	0.014
Average magnitude	0.007
RMS	0.009
Std deviations	0.009

Table 2: Control Points 2 compared with uncorrected data

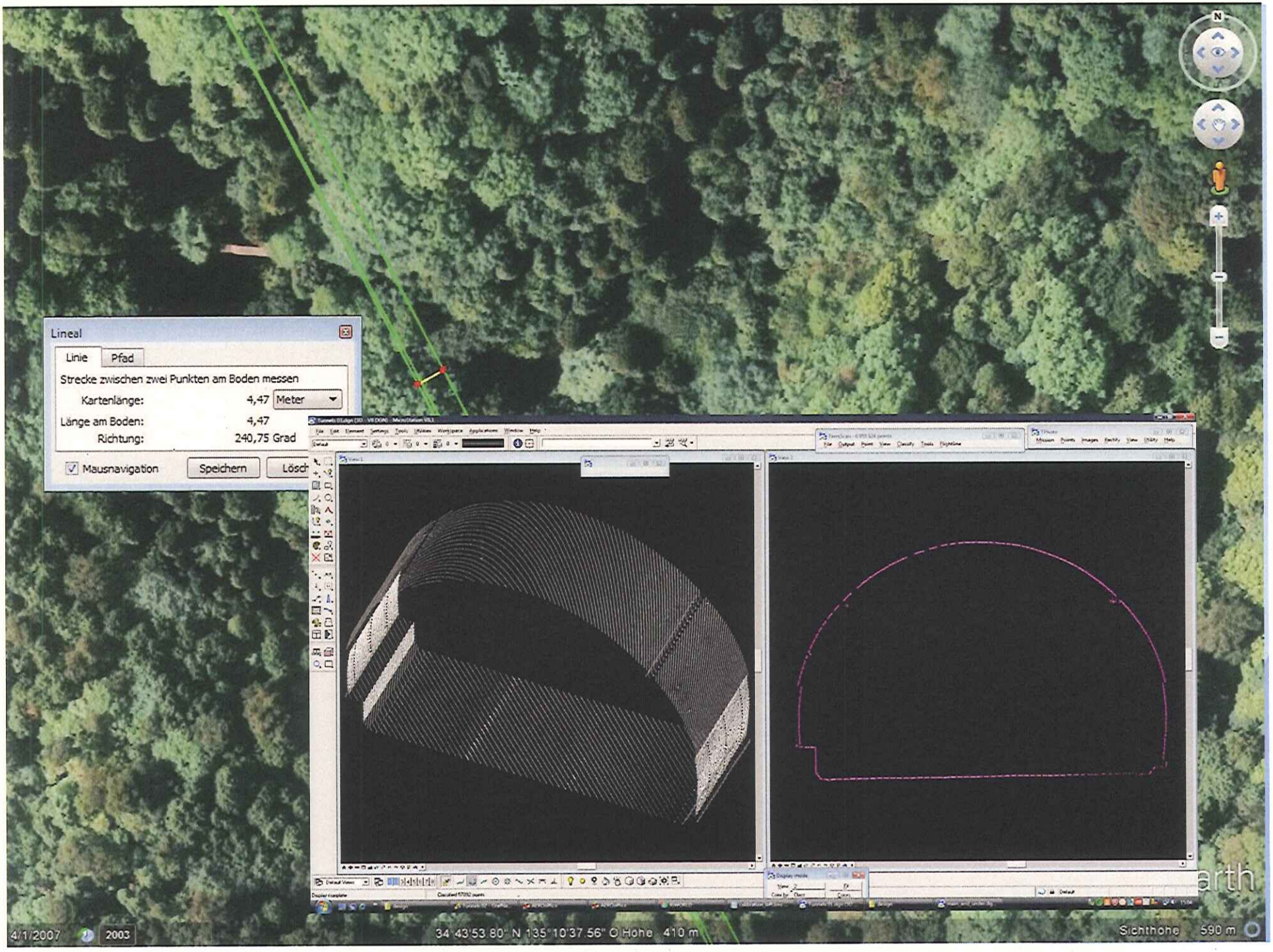
Average dz	-0.001
Minimum dz	-0.004
Maximum dz	0.003
Average magnitude	0.002
RMS	0.002
Std deviations	0.002

Table 3: Control Points 2 compared with corrected data

STREETMAPPER


N
Image © 2012 DigitalGlobe
Google earth
3/30/2010
2003
34 43'24.56" N 135 11'15.80" O Höhe 332 m
Sichthöhe 11.73 km


Gray Buildings © 2008 ZENRIN
Image © 2012 DigitalGlobe
Google earth
3/30/2010
2003
34°42'00.36" N 135°12'03.16" O Höhe 38 m
Sichthöhe 791 m


Lineal
Linie
Pfad
Strecke zwischen zwei Punkten am Boden messen
Kartenlänge: 4,47 Meter
Länge am Boden: 4,47
Richtung: 240,75 Grad
Mausnavigation
Speichern
Lösch
N
4/1/2007
2003
34°43'53.80" N 135°10'37.56" O Höhe 410 m
Sichthöhe 590 m

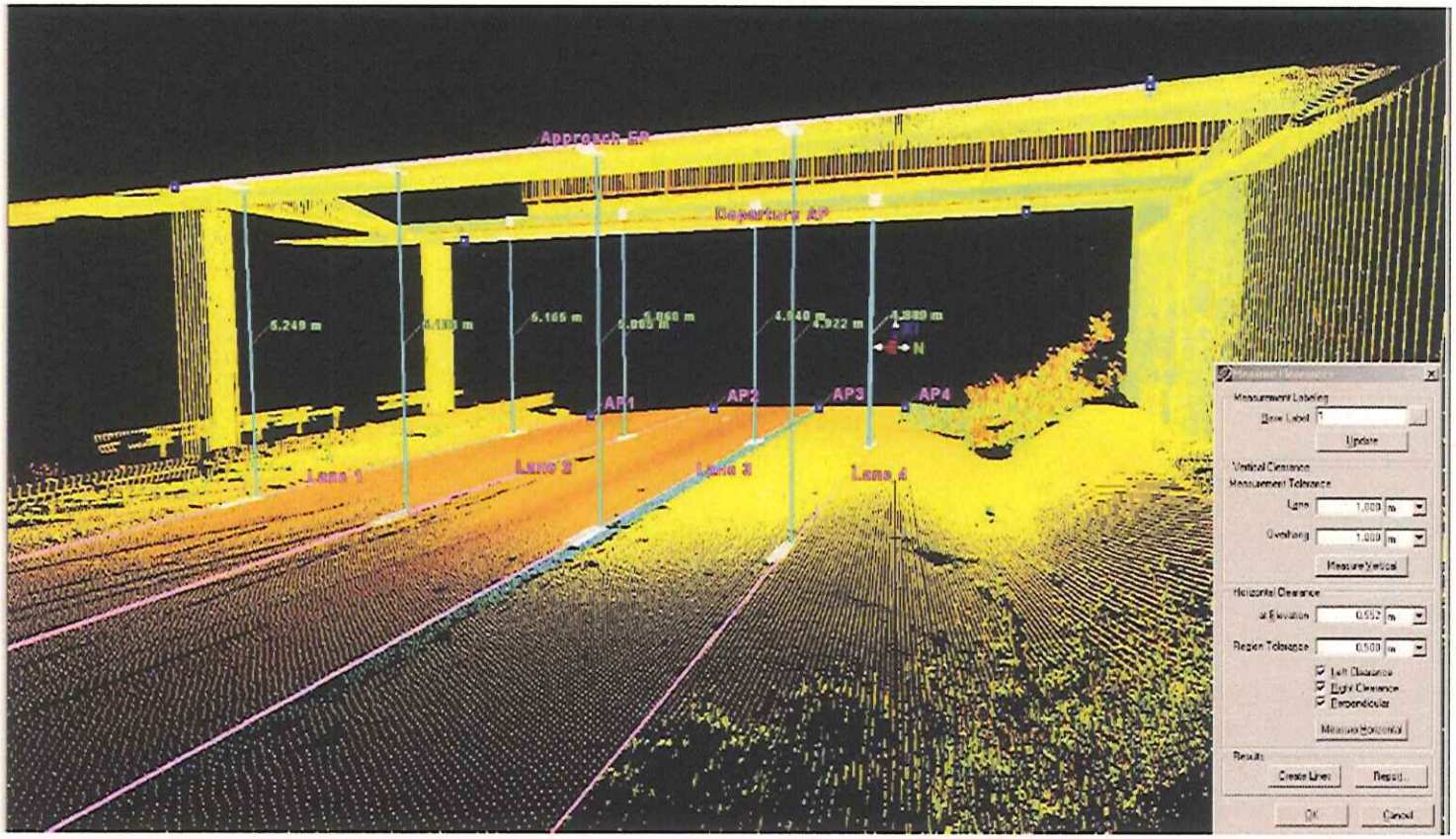
Straßen.NRW.
Landesbetrieb Straßenbau Nordrhein-Westfalen

Effiziente Bestandsdatenvermessung mit dem Mobile Mapping System „Streetmapper“ - Teil 1: Vorstellung von Ergebnissen -

Dr.-Ing. Brigitte Husen, Landesbetrieb Straßenbau NRW
Fachcenter Vermessung/Straßeninformationssysteme

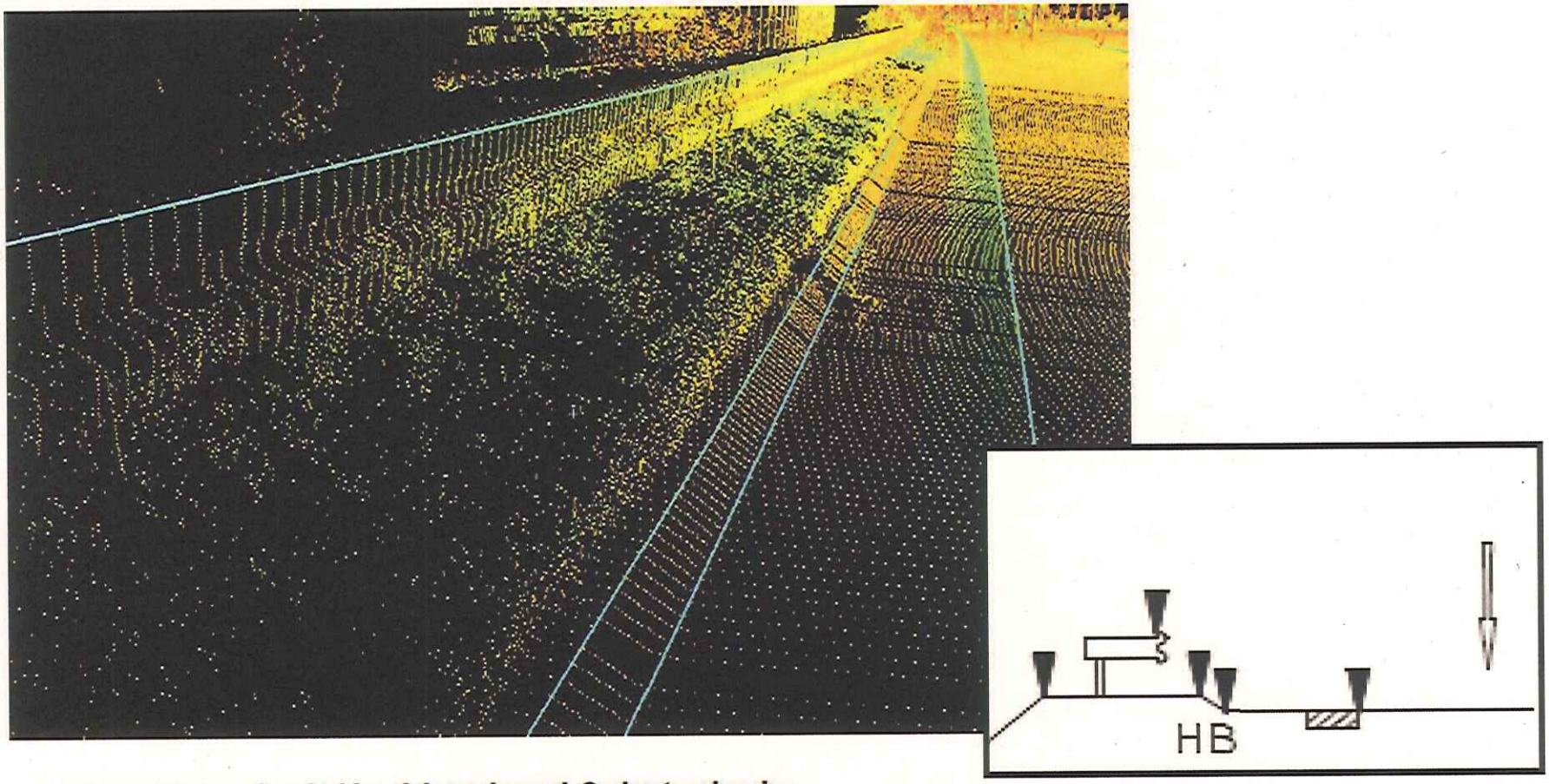
Durchfahrtshöhen

Straßen.NRW.
Landesbetrieb Straßenbau Nordrhein-Westfalen



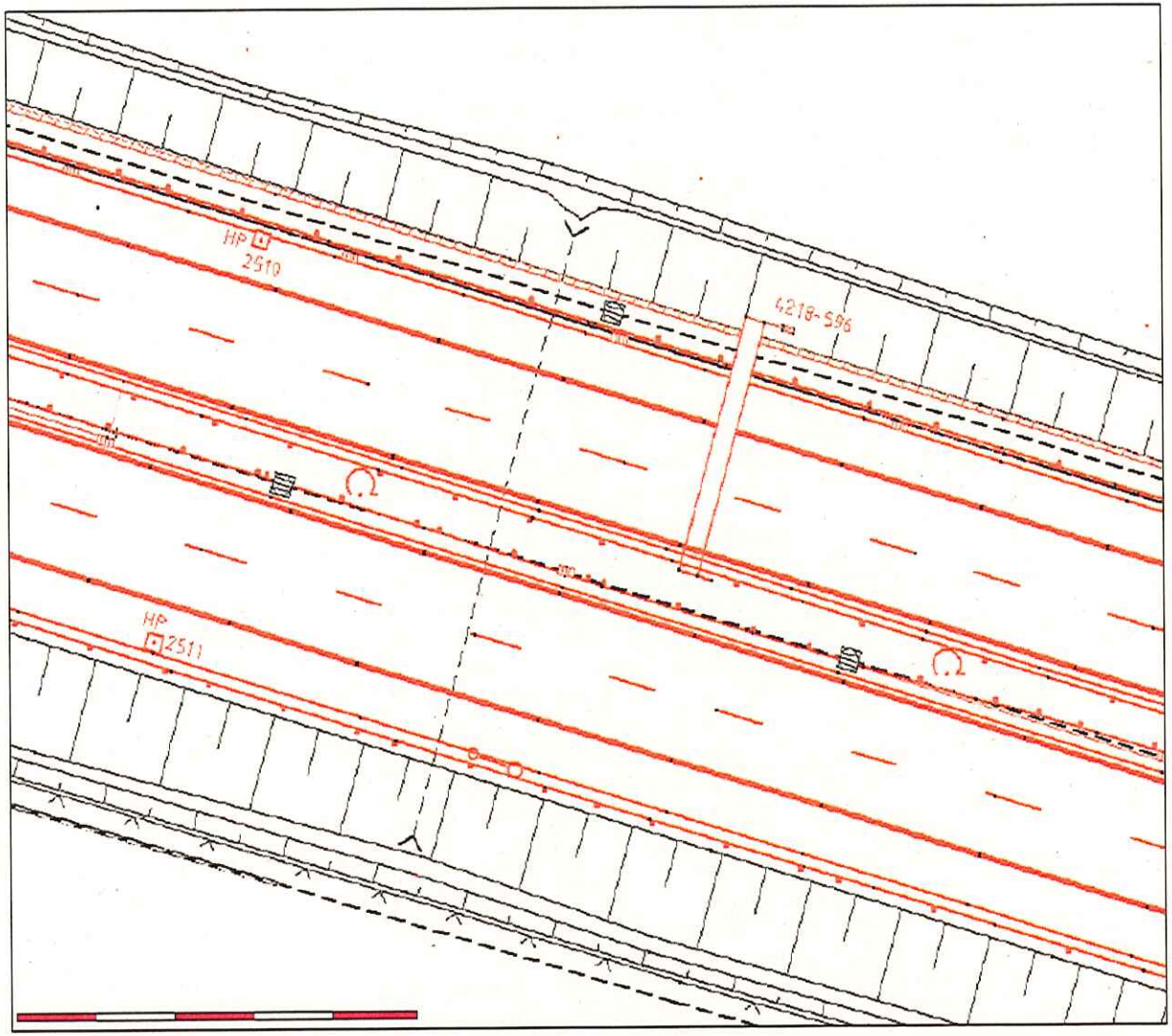
Detail: Fahrbahnrand

Straßen.NRW.
Landesbetrieb Straßenbau Nordrhein-Westfalen



Fahrbahnrand mit Hochbord und Schutzplanke

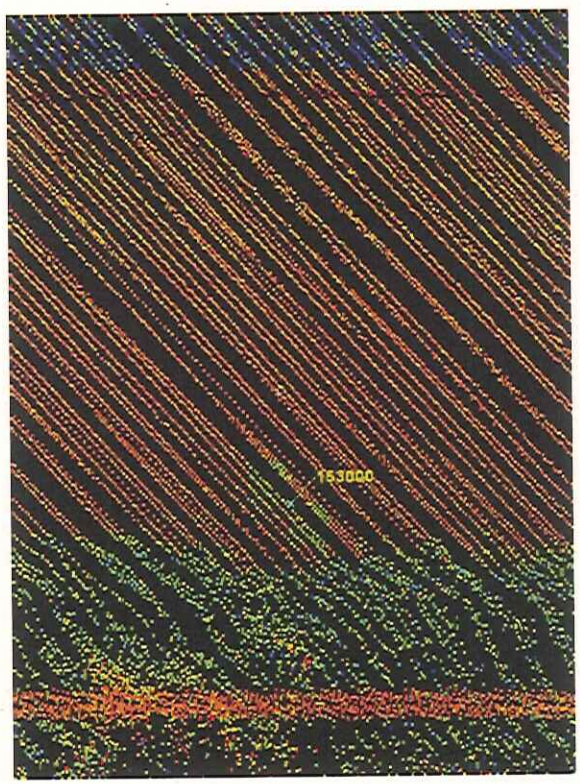
Bestandsplan (Ausschnitt)



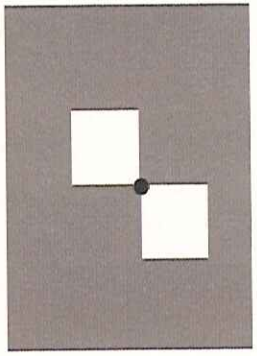
rot:
Objekte aus der Punktwolke erfasst.

schwarz:
Objekte mit Tachymeter/GPS gemessen.

Genauigkeit



Standstreifen (Ausschnitt)



Signalisierung

Genauigkeiten:

σ_R = 12 mm

σ_H = 21 mm

σ_h = 5 mm

Abweichungen an unabhängigen, signalisierten Kontrollpunkte

dR [cm]	dH [cm]	dh [cm]
0,1	1,4	-0,1
2,2	2,4	0,7
0,5	2,0	0,0
1,3	2,5	-0,6
0,2	3,1	0,1
-0,2	-1,5	-0,2
-2,1	1,5	-1,1
0,1	-0,8	0,2
-0,6	-0,2	-0,9
-1,1	-1,2	-1,1
-0,2	-3,7	0,4
-0,8	-1,5	-0,3
3,0	0,2	-0,1
-0,8	1,7	0,1
0,9	1,9	0,1
-0,4	2,1	-0,7
0,9	3,2	0,4
-1,7	3,2	-0,3

Conclusion

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- A careful system calibration is a prerequisite for high accuracy Mobile Mapping.

- Local adjustments are generally much more important for Mobile Mapping than for airborne LiDAR.

- Combining a high performance GNSS/INS with a state of the art LiDAR and the current calibration and adjustment techniques allows for cm accuracies for a wide range of project conditions.

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