

Appendix

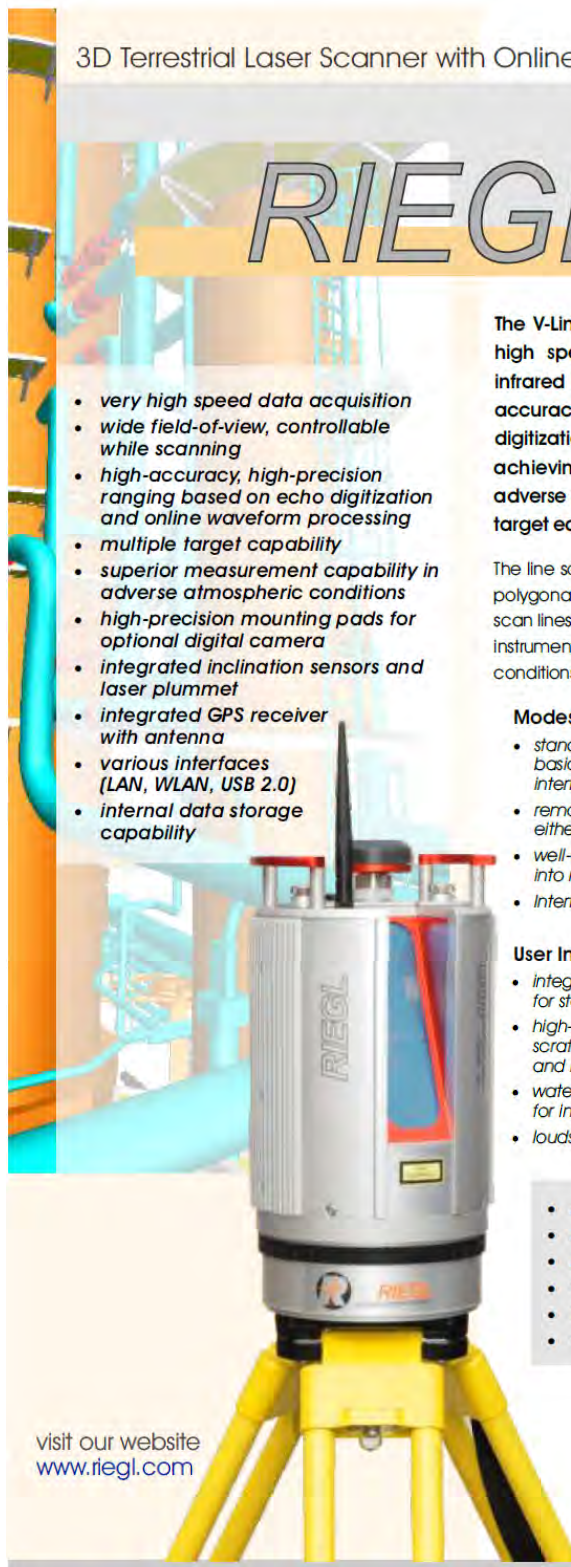
Appendix A-1

Data Sheets - Used Sensors

Data Sheet – RIEGL VZ-400

3D Terrestrial Laser Scanner with Online Waveform Processing

RIEGL VZ-400[®]



- very high speed data acquisition
- wide field-of-view, controllable while scanning
- high-accuracy, high-precision ranging based on echo digitization and online waveform processing
- multiple target capability
- superior measurement capability in adverse atmospheric conditions
- high-precision mounting pads for optional digital camera
- integrated inclination sensors and laser plummet
- integrated GPS receiver with antenna
- various interfaces (LAN, WLAN, USB 2.0)
- internal data storage capability

The V-Line[®] 3D Terrestrial Laser Scanner *RIEGL VZ-400* provides high speed, non-contact data acquisition using a narrow infrared laser beam and a fast scanning mechanism. High-accuracy laser ranging is based upon *RIEGL*'s unique echo digitization and online waveform processing, which allows achieving superior measurement capability even under adverse atmospheric conditions and the evaluation of multiple target echoes.

The line scanning mechanism is based upon a fast rotating multi-facet polygonal mirror, which provides fully linear, unidirectional and parallel scan lines. The *RIEGL VZ-400* is a very compact and lightweight surveying instrument, mountable in any orientation and even under limited space conditions.

Modes of Operation

- stand-alone data acquisition without the need of a notebook, basic configuration and commanding via the built-in user interface
- remote operation via *RISCAN PRO* on a notebook, connected either via LAN interface or integrated WLAN
- well-documented command interface for smooth integration into mobile laser scanning systems
- interfacing to Post Processing Software

User Interfaces

- integrated Human-Machine Interface (HMI) for stand-alone operation without computer
- high-resolution 3.5" TFT color display, 320 x 240 pixel, scratch resistant cover glass with anti-reflection coating and multi-lingual menu
- water and dirt resistant key pad with large buttons for instrument control
- loudspeaker for audible signaling of messages by voice

- As-Built Surveying
- Architecture & Facade Measurement
- Archaeology & Cultural Heritage Documentation
- City Modelling
- Tunnel Surveying
- Civil Engineering

visit our website
www.riegl.com



RIEGL[®]
LASER MEASUREMENT SYSTEMS

Terrestrial Laser Scanning

System Configuration



Scanner Hardware **RIEGL VZ-400**

allows high-speed, high resolution and accurate 3D measurements

- Range up to 600 m @ Laser Class 1
- Repeatability 3 mm
- Measurement rate up to 122.000 measurements/sec
- Field of View up to 100° x 360°
- LAN/WLAN data interface, easily allowing wireless data transmission
- Operated by any standard PC or Notebook or cable less
- Fully portable, rugged & robust

Software **RISCAN PRO**

RIEGL software package for scanner operation and data processing

- Data archiving using a well-documented tree structure in XML file format
- Object VIEW / INSPECTOR for intelligent data viewing and feature extraction
- Straightforward Global Registration
- Interfacing to Post Processing Software



Digital Camera (optional)

provides high resolution calibrated color images

- NIKON D700, NIKON D300(s)
 - D700: 12.1 Megapixel, Nikon FX format
 - D300(s): 12.3 Megapixel
 - USB interface

Mounting device with digital camera can be easily fixed by means of two knurled head screws. Precise position and orientation is provided by three supporting points. Power supply and USB 2.0 interface is provided by the scanner directly.

The combination of the key components **Scanner**, **Software** and **Camera** results in

- Automatic generation of high resolution textured meshes
- Photorealistic 3D reconstruction
- Exact identification of details
- Online position and distance measurements
- Online setting of any virtual point of view

Global Scan Position Registration



Stand-alone Registration

- integrated GPS receiver (L1)
- integrated biaxial inclination sensors (tilt range $\pm 10^\circ$, accuracy typ. $\pm 0.008^\circ$)
- RISCAN PRO Processing and Multistation Adjustment Module (MSA)

Registration via control points

- precise and fast fine scanning of retro-reflectors
- RISCAN PRO Processing

Totalstation-like-Registration

- setup above well known point (integrated laser plummet)
- integrated inclination sensors
- precise fine scanning of well known remote target (reflector)
- RISCAN PRO Processing Backsighting function

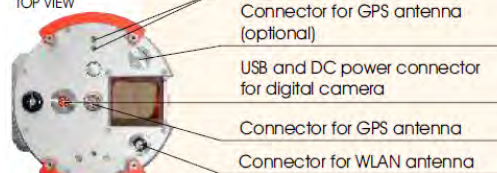
Operating Elements and Connectors



Communication and Interfaces

- LAN interface 10/100/1000 MBit/sec within rotating head
- LAN interface 10/100 MBit/sec within base
- Integrated WLAN interface with rod antenna
- USB 2.0 for external storage devices (USB flash drives, external HDD)
- USB 2.0 for connecting the optional digital camera
- connector for GPS antenna
- two connectors for external power supply
- connector for external GPS synchronization pulse (1PPS)

TOP VIEW



USB 2.0 slot for external memory devices



LAN 10/100/1000 MBit/sec, for rapid download of scan data

Scan Data Storage

- Internal 32 GByte flash memory (1 GByte reserved for the operating system)
- external storage devices (USB flash drives or external hard drives) via USB 2.0 interface

Power Supply

Add-on rechargeable battery

- optional add-on rechargeable battery pack (high power, high capacity NiMH cells)
- compact disc design, short-circuit-proof and protected connection pins
- rechargeable during standard scan operation via external power supply
- integrated micro-controller based charging electronics
- easily pluggable to base of the laser scanner by central locking screw
- DC voltage source (11-32 V DC) sufficient for recharging



External power supply

- Intelligent power supply management, up to three independent external power sources can be connected simultaneously for uninterrupted operation
- Reliable under- and over voltage protection
- Wide external voltage supply range 11-32 V DC
- Power consumption typ. 65 W
- LED indicators for power status

Technical Data 3D Scanner Hardware *RIEGL VZ[®]-400*

Laser Product Classification

Class 1 Laser Product according to IEC60825-1:2007

The following clause applies for instruments delivered into the United States:
Complies with 21 CFR 1040.10 and 1040.11 except for deviations pursuant
to Laser Notice No. 50, dated June 24, 2007.



Physical Data

temperature range 0°C to +40°C (operation), -10°C to +50°C (storage)
protection class IP64 (dust and splash-proof)
weight approx. 9.6 kg

Range Performance¹⁾

	Long Range Mode	High Speed Mode
Laser PRR (Peak) ²⁾	100 kHz	300 kHz
Effective Measurement Rate ²⁾	42 000 meas./sec	122 000 meas./sec
Max. Measurement Range ³⁾ for natural targets $\rho \geq 90\%$ for natural targets $\rho \geq 20\%$	600 m 280 m	350 m 160 m
Max. Number of Targets per Pulse	practically unlimited ⁴⁾	practically unlimited ⁴⁾
Accuracy ^{5) 7)}	5 mm	5 mm
Precision ^{6) 7)}	3 mm	3 mm

Minimum Range 1.5 m
Laser Wavelength near infrared
Beam Divergence⁸⁾ 0.3 mrad

1) with online waveform processing

2) rounded values

3) Typical values for average conditions. Maximum range is specified for flat targets with size in excess of the laser beam diameter, perpendicular angle of incidence, and for atmospheric visibility of 23 km. In bright sunlight, the max. range is shorter than under an overcast sky.

4) details on request

5) Accuracy is the degree of conformity of a measured quantity to its actual (true) value.

6) Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.

7) One sigma @ 100 m range under RIEGL test conditions.

8) 0.3 mrad correspond to 30 mm increase of beamwidth per 100 m of range.

Scan Performance

Scan Angle Range
Scanning Mechanism
Scan Speed
Angular Stepwidth $\Delta \theta$ (vertical), $\Delta \phi$ (horizontal)

Angle Measurement Resolution

Inclination Sensors

GPS receiver

Compass

Internal Sync Timer

Scan Sync (optional)

Vertical (Line) Scan
total 100° (+60° / -40°)
rotating multi-facet mirror
3 lines/sec to 120 lines/sec
 $0.0024^\circ \leq \Delta \theta \leq 0.288^\circ$ ⁹⁾
between consecutive laser shots
better 0.0005° (1.8 arcsec)

Horizontal (Frame) Scan
max. 360°
rotating head
0°/sec to 60°/sec¹⁰⁾
 $0.0024^\circ \leq \Delta \phi \leq 0.5^\circ$ ⁹⁾
between consecutive scan lines
better 0.0005° (1.8 arcsec)

integrated, for vertical scanner setup position

integrated, L1 antenna

optional, for vertical scanner setup position

integrated real-time synchronized time stamping of scan data

scanner rotation synchronization

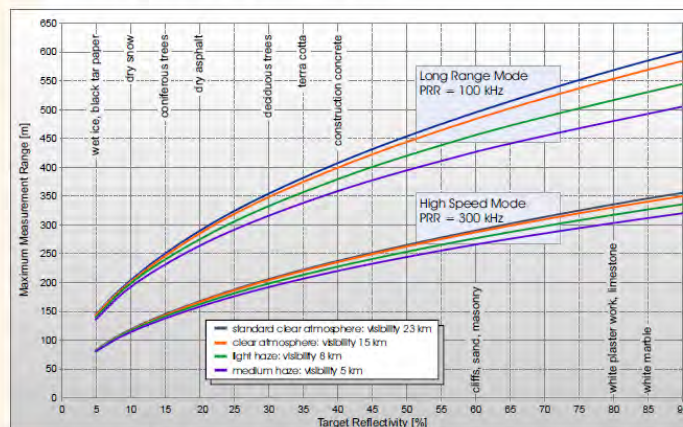
9) selectable

10) frame scan can be disabled, providing 2D operation

Max. Measurement Range

The following conditions are assumed:

Flat target larger than footprint of laser beam,
perpendicular angle of incidence,
average brightness



RIEGL[®]
LASER MEASUREMENT SYSTEMS

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Data Sheet – IXSEA HYDRINS



HYDRINS

HYDROGRAPHIC SURVEY / MULTIBEAM SURVEY

HYDRINS is a high performance Inertial Navigation System optimised for hydrographic survey using multibeam echosounders. HYDRINS comprises a single compact unit and delivers highly accurate real time position, attitude and velocity data. In addition to the real-time options, HYDRINS raw data can be post-processed using IXSEA DELPH INS.

FEATURES

- Proven high performance IXSEA INS technology inside
- Compact, uses any kind of GPS (only one GPS required)
- DELPH INS (Windows based) post processing package included
- GPS drop-out / multipath management
- Ethernet, WEB-based MMI (Man Machine Interface)

BENEFITS

- Reliable and accurate motion, speed, position and heave data
- Fast and reliable installation on all vessels
- A complete solution packed with easy to use yet powerful post-processing tools
- Motion and heading not affected by GPS outages, position remains valid for minutes
- Network ready, intuitive user interface



APPLICATIONS • Multibeam survey • Hydrographic survey • Harbours and inland waterways

HYDRINS

TECHNICAL SPECIFICATIONS



IMO Certified
N° 19111/A1 EC
N° 19184/A1 EC

PERFORMANCE

Position accuracy Real Time ⁽¹⁾	
With GPS	3 times better than GPS
No aiding for 1 min / 2 min	0.8 m / 3.2 m
Position accuracy Post Processed ⁽¹⁾	
With GPS	4 times better than GPS
No aiding for 1 min / 2 min	0.2 m / 1m
Heading accuracy ⁽²⁾⁽³⁾	0.02 deg secant latitude
Roll and Pitch dynamic accuracy ⁽²⁾	0.01 deg
Heave accuracy (Smart Heave) ⁽⁴⁾	2.5cm or 2.5%

OPERATING RANGE / ENVIRONMENT

Operating / Storage Temperature	20 to 55 °C / 40 to 80 °C
Rotation rate dynamic range	Up to 750 deg/s
Acceleration dynamic range	± 15 g
Heading / Roll / Pitch	0 to ±360 deg / ±180 deg / ±90 deg
MTBF (computed/observed)	40,000/80,000 hours
No warm-up effects	
Shock and Vibration proof	

PHYSICAL CHARACTERISTICS

Dimensions (L x W x H)	180 x 180 x 160 mm
Waterproof	IP66
Weight	4.5 kg
Material	Aluminium

INTERFACES

Serial RS232 or RS422	5 inputs / 5 outputs / 1 configuration port
Ethernet Port ⁽⁵⁾	UDP / TCP Client / TCP server
Pulse port ⁽⁶⁾	4 inputs and 2 outputs
Sensors supported	GPS
Input / Output formats	Industry standards: NMEA0183, ASCII, BINARY
Baud rates	600 bauds to 115.2 kbaud
Data output rate	0.1 Hz to 200 Hz
Power supply	24 VDC
Power consumption	15 W

(1) CEP: 50 % circular Error Probability

(2) Heading, Roll, Pitch figures are RMS values

(3) Secant latitude ± 1 / cosine latitude

(4) Whichever is greater for periods up to 30 seconds. Smart Heave is delayed by 100 s fixed value.

Real time heave accuracy is 5 cm or 5% whichever is greater

(5) All input/output serial ports are available and can be duplicated on Ethernet ports

(6) Use GPS PPS pulse for accurate time synchronization of HYDRINS

Specifications subject to change without notice

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Data Sheet – TRIMBLE SPS851



KEY FEATURES

- Highly flexible base or rover receiver for construction site measurement applications and system integrators
- Separate antennas and receiver for maximum radio coverage and security on the job site
- Integrated license-free 900 MHz or 450 MHz UHF radio for base and rover tasks
- Rapid daily base station setup with a single button push using AutoBase™ technology
- Internet enabled base station via Ethernet or GSM/GPRS phone
- Supports GPS and L2C Modernized GPS signals
- Trimble SPS851 can be upgraded with GLONASS or L5 signals
- Integrated battery that also acts as a IIPS power supply
- IIPS output for time synchronization with other devices



FLEXIBLE GPS RECEIVER FOR PRECISE POSITIONING

Trimble® SPS751 and SPS851 Modular GPS Receivers are ideal for semi-permanent or permanent base station setups, construction rover applications as well as marine based applications.

Now heavy and highway contractors have the ideal base station to support grade checking, site measurement and stakeout. The receivers can be utilized as a rover with a controller in a site supervisors vehicle or on a pole.

Modular Design Means Flexible Set Up

The Trimble SPS751 and SPS851 receivers combine the radio and GPS receiver in a single housing. This allows contractors to secure the majority of their investment inside a site trailer or carrying case, protected from the elements and theft, leaving only the antennas outside. The antennas can now be located clear of obstructions and provide maximum radio coverage on site.

A future-proof investment

Available in a range of options to suit your construction application and performance requirements, versatile Trimble GPS receivers are a future-proof investment.

The SPS851 Modular GPS Receiver is designed to receive current and future satellite signals. This receiver supports GPS modernization through support of L2C code and can be upgraded to receive GLONASS or L5 GPS signals, protecting your investment well into the future.

The SPS751 is available in three models to suit specific budget and application requirements. All models support GPS modernization through support of L2C code. The SPS751 Basic Rover and Basic Base can be upgraded to the SPS751 Max giving you flexibility to swap between base and rover functionality as work demands.

Get Connected, Stay Connected

The SPS751 and SPS851 each contain a built-in powerful web server component that enables increased operational efficiency and flexibility. Using this Internet-enabled base station allows for remote configuration and monitoring, eliminating the need for time-consuming and costly visits to the base station to set up each day or diagnose issues that may arise. Internet base stations can provide corrections to multiple jobsites in the same vicinity or provide corrections to cell phone enabled rovers in areas of radio blackout.

Larger site operations or system integrators can configure and monitor the quality of the system or utilize its multiple modes of operation by accessing the internal web server.

Improved GPS Performance

The new Trimble RTK engine improves performance under tree canopy and reduces initialization time after loss of lock, delivering high performance in a variety of measurement conditions. Combined with integrated 450 MHz UHF or license-free 900 MHz radio communications options these features make the receivers easier to use, faster to setup and more productive during measurement and stakeout.



TRIMBLE SPS751 AND SPS851 MODULAR GPS RECEIVERS

UNIQUE PERFORMANCE SPECIFICATIONS

SPS751 Basic Modular GPS Receiver

Base and Rover interchangeability	No
Base only operation	SPS751 Basic Base
Rover only operation	SPS751 Basic Rover
Rover position update rate	1 Hz, 2 Hz
Rover maximum range from base	2.4 km (1.5 mile)
Rover operation within a VRS™ network	No

SPS751 Max Modular GPS Receiver

Base and Rover interchangeability	Yes
Rover position update rate	1 Hz, 2 Hz, 5 Hz, 10 Hz
Rover maximum range from base	Unrestricted
Typical range 2 – 5 km (1.2 – 3 miles) without radio repeater	
Rover operation within a VRS network	Yes

SPS851 Modular GPS Receiver

Upgrade options	L5 GPS Full Cycle Carrier GLONASS L1/L2
Base and Rover interchangeability	Yes
Rover position update rate	1 Hz, 2 Hz, 5 Hz, 10 Hz, 20 Hz
Rover maximum range from base	Unrestricted
Typical range 2 – 5 km (1.2 – 3 miles) without radio repeater	
Rover operation within a VRS network	Yes

COMMON PERFORMANCE SPECIFICATIONS

General

Keyboard and display	VFD display 16 characters by 2 rows On/Off key for one button start up Escape and Enter key for menu navigation 4 arrow keys (up, down, left, right) for option scrolls and data entry
Dimensions (L x W x D)	24 cm x 12 cm x 5 cm (9.4 in x 4.7 in x 1.9 in)
Weight	1.65 kg (3.64 lb) receiver including connectors 1.55 kg (3.42 lb) receiver with internal battery and no radio

Antenna options

L1/L2/L2C GPS, GLONASS and OmniSTAR operation	Zephyr™ Model 2
L1/L2/L2C GPS and GLONASS Base Station	Zephyr Geodetic™ Model 2
Supports legacy Trimble antennas	Zephyr, Zephyr Geodetic, Z4, Micro-Centered™ Choke ring, Rugged Micro-Centered GPS L1/L2

Temperature

Operating ¹	-40 °C to +65 °C (-40 °F to +149 °F)
Storage	-40 °C to +80 °C (-40 °F to +176 °F)
Humidity	MIL-STD 810F, Method 507.4
Waterproof	IP67 for submersion to depth of 1 m (3.3 ft), dustproof

Shock and vibration

Designed to survive a 1 m (3.3 ft) pole drop onto a hard surface

Shock: non-operating	To 75 g, 6 ms
Shock: operating	To 40 g, 10 ms, saw-tooth
Vibration	Tested to Trimble ATV profile (4.5 gRMS): 10 Hz–300 Hz: 0.04 g/2Hz; 300 Hz–1,000 Hz: ~6 dB/octave

Measurements

- Advanced Trimble Maxwell™ 5 Custom GPS chip
- High-precision multiple correlator for L1/L2 pseudo-range measurements
- Unfiltered, unsmoothed pseudo-range measurements data for low noise, low multipath error, low time domain correlation, and high dynamic response
- Very low noise carrier phase measurements with <1 mm precision in a 1 Hz bandwidth
- L1/L2 signal-to-noise ratios reported in dB-Hz
- Proven Trimble low elevation tracking technology
- 72-channel L1 C/A code, L1/L2/L2C Full Cycle Carrier. Upgradable to GLONASS L1/L2 Full Cycle Carrier.
- Trimble EVEREST™ multipath signal rejection
- 4-channel SBAS (WAAS/EGNOS/MSAS)

Code differential GPS positioning²

Horizontal accuracy	0.25 m + 1 ppm RMS (0.8 ft + 1 ppm RMS)
Vertical accuracy	0.50 m + 1 ppm RMS (1.6 ft + 1 ppm RMS)

SBAS (WAAS/EGNOS/MSAS) positioning³

Horizontal accuracy	Typically <1 m (3.3 ft)
Vertical accuracy	Typically <5 m (16.4 ft)

OmniSTAR positioning

VBS service accuracy	Horizontal <1 m (3.3 ft)
XP service accuracy	Horizontal 0.2 m (0.66 ft), Vertical 0.3 m (1.0 ft)
HP service accuracy	Horizontal 0.1 m (0.33 ft), Vertical 0.15 m (0.5 ft)

Real-Time Kinematic (RTK) positioning

Horizontal accuracy	10 mm + 1 ppm RMS (0.032 ft + 1 ppm RMS)
Vertical accuracy	20 mm + 1 ppm RMS (0.065 ft + 1 ppm RMS)

Initialization time

Regular RTK operation with base station	Single/Multi-base minimum 10 seconds + 0.5 times baseline length in km, up to 30 km
RTK operation with Scalable GPS infrastructure	Typically <30 seconds anywhere within coverage area (SPS751 Max and SPS851 only)
Initialization reliability ⁴	>99.9%

TRIMBLE SP5751 AND SP5851 MODULAR GPS RECEIVERS

Power

Internal

- Integrated internal battery 7.2 V, 7800 mA-hr, Lithium-ion
- Internal battery operates as a UPS in the event of external power source failure
- Internal battery will charge from external power source when input voltage is >15 V
- Integrated charging circuitry

External

- Power input on 7-pin D-shell Lemo connector is optimized for lead acid batteries with a cut-off threshold of 10.5 V
- Power input on the 26-pin D-sub connector is optimized for Trimble Lithium-ion battery input with a cut-off threshold of 9.5 V
- Power source supply (Internal/External) is hot-swap capable in the event of power source removal or cut off
- 9.5 V to 28 V DC external power input with over-voltage protection
- Receiver will automatically turn on when connected to external power

Power consumption 6.0 W in rover mode
with internal receive radio
8.0 W in base mode
with internal transmit radio

Operation time on internal battery

Rover 13 hours; varies with temperature

Base station (SP5851 with GPS and GLONASS):

450 MHz systems¹ Approximately 11 hours; varies with temperature
900 MHz systems Approximately 9 hours; varies with temperature

Regulatory approvals

- FCC: Part 15 Subpart R (Class B Device) and Subpart C, Part 90
- Industry Canada: ICES-003 (Class B Device), RSS-210, RSS-Ges, RSS-310, RSS-119
- R&TTE Directive: EN 301 489-1/-5/-17, EN 300 440, EN 300 320, EN 300 113, EN 60950, EN 50371
- ACMA: AS/NZS 4295 approval
- CE mark compliance
- C-tick mark compliance
- UN ST/SG/AC.10.1/Rev. 3, Amend. 1 (Lithium-ion Battery)
- UN ST/SG/AC.10.2/Rev. 2 (Lithium-ion Battery)
- RoHS compliant (excludes those with an internal 900 MHz radio)
- WEEE compliant

Communications

Port 1 (7 pin US Lemo)

Serial 1 3 wire RS-232

Port 2 (26 pin D-sub)

Serial 2 Full 9 wire RS-232

Serial 3 3 wire RS-232

1PPS (pulse per second) via adapter cable

USB (On the Go) via multi-port adapter

Ethernet via multi-port adapter

Bluetooth Fully integrated, fully-sealed

2.4 GHz Bluetooth[®] module

Integrated radios (optional) Fully integrated, fully sealed

internal 450 MHz (UHF) Tx/Rx,

internal 900 MHz Tx/Rx

Channel spacing (450 MHz) 12.5 KHz or 25 KHz

spacing available

450 MHz output power 0.5 W, 2.0 W

(2.0 W available only in certain countries)

900 MHz output power 1.0 W

(2.0 W available only in certain countries)

Frequency approvals (900 MHz) USA/Canada (-10)

New Zealand/Australia (-20)

Australia (-30)

External GSM/GPRS, cell phone support Supported for direct dial and

Internet-based correction streams

Cellular phone or GSM/GPRS modem inside TSC2 controller

Receiver position update rate 1 Hz, 2 Hz, 5 Hz,

10 and 20 Hz positioning

Correction data input CMR[™], CMR+[™], RTCM 3, RTCM 2 x

Correction data output CMR/CMR+, RTCM 2.x

Data outputs NMEA, GSOE, 1PPS Time Tags

Receiver options and upgrades

SP5751 Basic to SP5751 Max Adds Base/Rover and VRS capability, high update rate and unrestricted range

SP5851 GLONASS upgrade Uses GLONASS L1/L2 satellite signals

SP5851 L5 upgrade Capable of tracking GPS modernization L5 signals

Internal Data Logging 2 MB for SP5751 Max

28 MB for SP5851

¹ Receiver will operate normally to -40°C. Internal batteries are rated to -20°C.

² Accuracy and reliability may be subject to anomalies such as multipath, obstructions, satellite geometry, and atmospheric conditions. Always follow recommended practices.

³ Depends on SBAS system performance.

⁴ May be affected by atmospheric conditions, signal multipath, and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.

⁵ If your receiver has the 2.0 W upgrade, you will experience reduced battery performance compared to the 0.5 W solution.

⁶ Bluetooth type approvals are country-specific. For more information, contact your local Trimble office or representative.

Specifications subject to change without notice.

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Data Sheet – RESON Seabat 8101



SeaBat 8101

- Phase and amplitude bottom detection
- 150° swath coverage (upgradeable to 210°)
- 240kHz frequency
- Up to 600m swath width (with Option 040)
- Meets IHO & USACE Class 1 standards

The SeaBat 8101 Multibeam Echosounder measures discrete depths, enabling complex underwater features to be mapped with precision. Dense coverage is achieved utilizing up to 4,000 soundings per second for a swath up to 600 meters in width, even as the survey vessel travels at speeds in excess of 12 knots.

With high accuracy and a measurement rate of up to 40 profiles per second, the SeaBat 8101 enables surveys to be completed faster and in greater detail than previously realized.

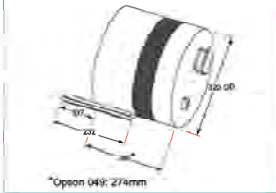
The SeaBat 8101 transducer is available for operating depths of 120, 300, 1500, and 3,000 meters. Small and lightweight, it can be mounted on underwater vehicles (ROV or towed) and transported to locations where accurate measurements are required.





SeaBat 8101

Multibeam Echosounder


SYSTEM PERFORMANCE

Operating Frequency:	240kHz	
Swath Coverage:	150°	(upgradeable to 210°)
Max Range:	3000m	
	450m max range available with ER option	
Number of Beams:	101, beamspacing 1.5°	
Along-Track Beamwidth:	1.5°	
Across-Track Beamwidth:	1.5°	
Max. Update Rate:	40	
Operational Speed:	Up to 18 knots	

PROCESSOR SPECIFICATIONS

Power Required:	100/240VAC, 47/63Hz, 100W maximum	
Data Uplink:	High-speed digital coax with fiber-optic option	
Computer Interface:	16MB Ethernet and RS232C	
Data Downlink:	Serial, 19.2K baud	
Display Video Out:	SVGA; 800 x 600	
	Refresh Rate:	~79Hz
Graphics Colors:	Sonar Images:	256 Colors
	Other Graphics:	8-bit RGB
Input Device:	3-Button Trackball	
Dimensions (HWD):	177 x 483 x 417mm	
Mounting:	19in. rack mountable	
Temperature:	Operating:	0° to +40°C
	Storage:	-30° to +65°C
Weight:	20kg (44 lbs.)	

DISPLAY SPECIFICATIONS

Screen Size:	14" diagonal	
Display:	8VGA High-Resolution, Color Monitor	
Power Consumption:	80W	
Weight:	11.2kg (24.6lbs.)	

SONARHEAD SPECIFICATIONS

Power Requirements:	24VDC, 2 amps max. (Power available from Processor.)	
Operating Depth:	120m (300, 1500, and 3000m available)	
Dimensions:	206 x 320mm (W / D) excluding projector	
Temperature:	Operating:	-5° to +40°C
	Storage:	-30° to +55°C
Weight (aluminum):	Dry:	26.8kg (59lbs.)
	Wet:	4.8kg (10.6lbs.)
Weight (titanium):	Dry:	40kg (88lbs.)
	Wet:	18kg (39.6lbs.)

OPTIONS

Sidescan upgrade	Mounting plate assembly
Fairings	Spares kit
Titanium housing	210° swath
Extended-Range (ER) projector	Coax to fiber optic interface unit
Increase sonar head depth rating	

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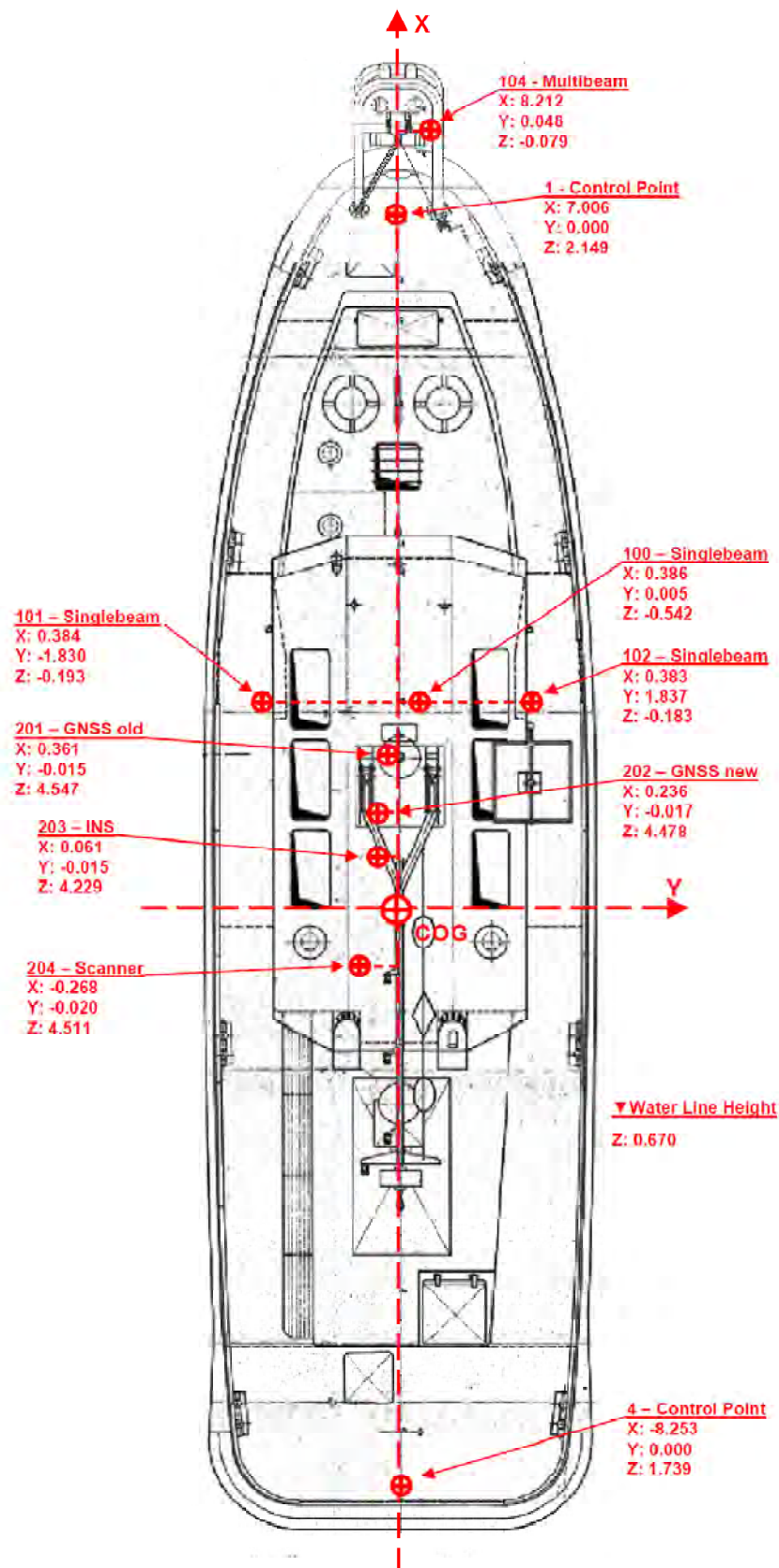
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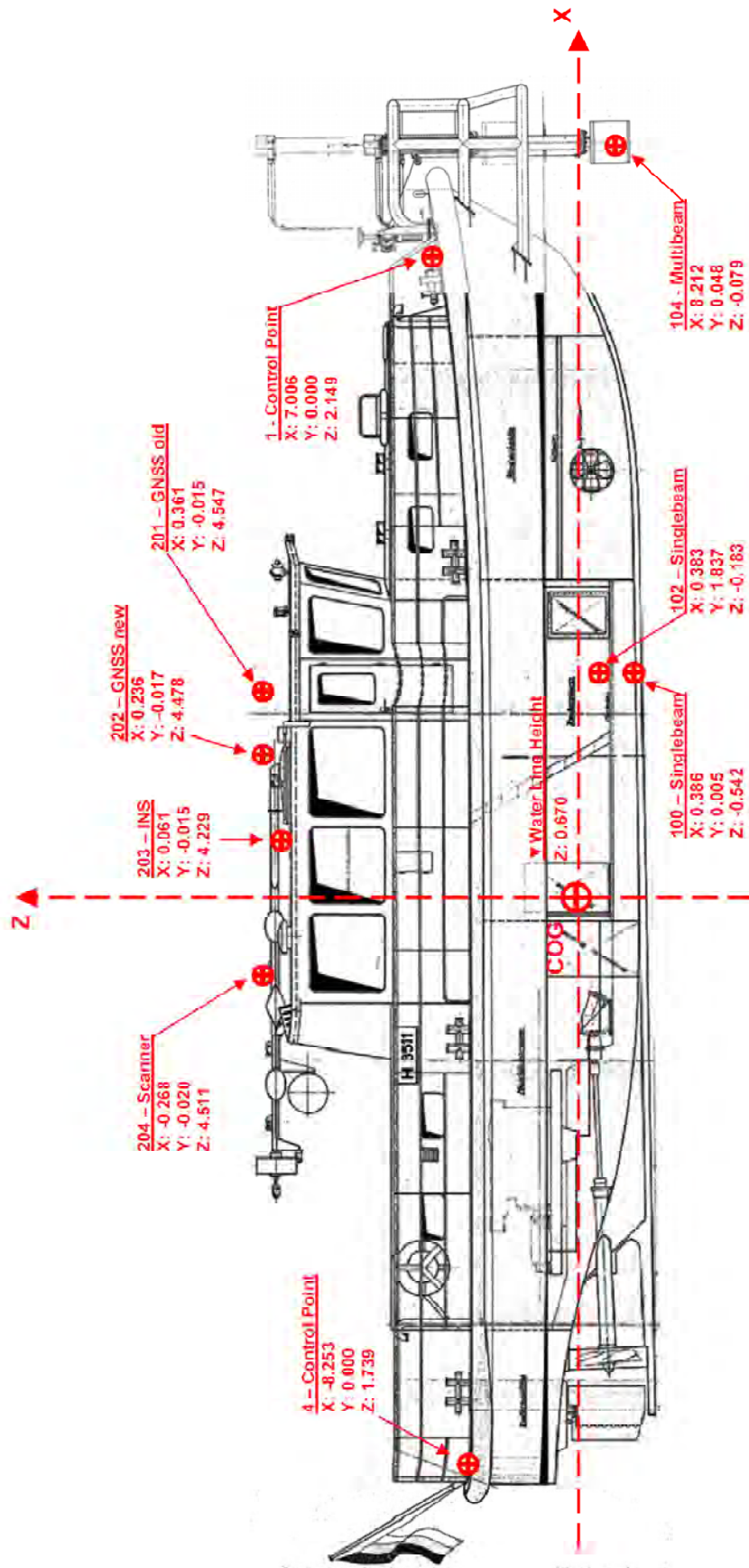
Appendix A-2

Initial Lever Arm Measurement

Lever Arms “Deepenschriewer III” – Top View



Lever Arms “Deepenschriewer III” – Side View



Appendix A-3

Uncertainty Computations

$$P = \begin{bmatrix} X_{\text{res}} + \Delta X_{\text{res-laser}} + R \cdot \sin(\Theta) \cdot \cos(\Phi) \\ Y_{\text{res}} + \Delta Y_{\text{res-laser}} + R \cdot \sin(\Theta) \cdot \sin(\Phi) \\ Z_{\text{res}} + \Delta Z_{\text{res-laser}} + R \cdot \cos(\Theta) \end{bmatrix}$$

$$R = \begin{bmatrix} \sin(\nu) \cdot \sin(\theta) + \cos(\phi) \cdot \cos(\psi) & \cos(\phi) \cdot \sin(\theta) - \sin(\psi) \cdot \sin(\phi) \\ \sin(\nu) \cdot \cos(\theta) & \cos(\psi) \cdot \cos(\phi) - \sin(\psi) \cdot \sin(\phi) \\ \sin(\nu) \cdot \sin(\theta) - \cos(\phi) \cdot \sin(\psi) & \cos(\psi) \cdot \sin(\phi) + \sin(\nu) \cdot \cos(\phi) \end{bmatrix}$$

Initial Parameters:

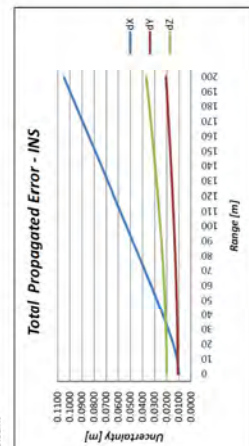
System	Parameter	value	Unit	Read
Laser Scanner	Range R	100	m	
	α R-B	0.005	m	
	Pan Ang. Θ -E	0	°	0.00000000
	α Θ -E	0.001	°	0.00001745
Motion Sensor / INS	Tilt Ang. Θ -D	90	°	1.57079633
	α Θ -D	0.001	°	0.00001745
	Pitch ϕ -A	3.58	°	0.06248279
	α ϕ -A	0.010	°	0.00017453
	Roll θ -C	0.07	°	0.00034907
	α θ -C	0.010	°	0.00017453
	Yaw ψ -B	269.84	°	4.70959645
	α ψ -B	0.034	°	0.00059341
Offsets	X mmu-las-xm	-0.329	m	
	α Xmmu-las-xm	0.001	m	
	Y mmu-las-ym	-0.005	m	
	α Ymmu-las-ym	0.001	m	
GNSS/IMU	Z mmu-las-zm	0.282	m	
	α Zmmu-las-zm	0.001	m	
	α Xgpus-Sdg	0.01	m	
	α Ygpus-Sdg	0.01	m	

Results of Uncertainty Computation

INS Accuracy, Laser Tilt 60°, Laser Pan 0°

Range	ΔX 60°	ΔY 60°	ΔZ 60°
0	0.0101	0.0109	0.0202
10	0.0114	0.0110	0.0202
20	0.0146	0.0111	0.0204
30	0.0187	0.0113	0.0207
40	0.0238	0.0115	0.0211
50	0.0281	0.0118	0.0216
60	0.0330	0.0123	0.0222
70	0.0380	0.0126	0.0229
80	0.0430	0.0130	0.0237
90	0.0481	0.0133	0.0245
100	0.0533	0.0141	0.0254
110	0.0584	0.0146	0.0264
120	0.0635	0.0151	0.0274
130	0.0686	0.0156	0.0285
140	0.0736	0.0162	0.0296
150	0.0786	0.0171	0.0308
160	0.0847	0.0178	0.0320
170	0.0894	0.0185	0.0332
180	0.0946	0.0193	0.0344
190	0.0998	0.0200	0.0357
200	0.1050	0.0207	0.0370

INS

Roll / Pitch = +0.01°
Heading = +0.034°
X, Y = +0.01m
Z = +0.02m

Coefficients of Rotation Matrix R based on Initial Parameters:

	R[1,1]	R[1,2]	R[1,3]	R[2,1]	R[2,2]	R[2,3]	R[3,1]	R[3,2]	R[3,3]
	-0.00281	-0.99804	0.06244	-1.00000	-0.00279	-0.00035	-0.00017	-0.06244	0.99805

Coefficients of Rotation Matrix R derived with respect to: ϕ -A, θ -C and ψ -B based on Initial Parameters:

	R[1,1,A]	R[1,1,C]	R[1,1,B]	R[1,2,C]	R[1,2,B]	R[1,3,C]	R[1,3,B]
	-0.06279	-0.06244	0.99804	-0.0624	-0.00017437	0.00281	-0.00002
	R[2,1,A]	R[2,1,C]	R[2,1,B]	R[2,2,C]	R[2,2,B]	R[2,3,C]	R[2,3,B]
	0	0.00035	-0.00279	0	0.00000	1.00000	-0.00000
	R[3,1,A]	R[3,1,C]	R[3,1,B]	R[3,2,C]	R[3,2,B]	R[3,3,C]	R[3,3,B]
	0.00281	-0.99804	-0.06244	-0.99804	-0.00279	0.00017	-0.06244

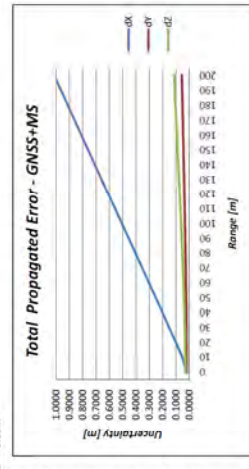
Coefficients of Position Vector P derived with respect to: R, Θ -D and Ψ -E based on Initial Parameters:

	P[X], R	P[Y], Θ -D	P[Z], Θ -E	P[Y], Θ -D	P[Z], Θ -E	P[Z], Θ -D
	1.00000	0.00000	0.00000	0.00000	100.00000	-100.00000
	P[X], Xm	P[Y], Ym	P[Z], Zm	P[Y], Ym	P[Z], Zm	P[Z], Zm
	1	0	0	0	0	0
	P[X], Xml	P[Y], Yml	P[Z], Zml	P[Y], Yml	P[Z], Zml	P[Z], Zml
	1	0	0	0	0	0

Partial Derivations of Result Vector R*P with Respect to each Parameter based on Initial Parameters:

	$\Delta X/\Delta R$	$\Delta X/\Delta \Theta$ -D	$\Delta X/\Delta \Psi$ -E	$\Delta X/\Delta \phi$ -A	$\Delta X/\Delta \theta$ -C	$\Delta X/\Delta \psi$ -B	$\Delta X/\Delta R$	$\Delta X/\Delta \Theta$ -D	$\Delta X/\Delta \Psi$ -E
	-0.00281	-6.24421	-99.80448	-5.97463	-6.22365	99.47609	-0.00281	-0.99804	0.06244
	$\Delta Y/\Delta R$	$\Delta Y/\Delta \Theta$ -D	$\Delta Y/\Delta \Psi$ -E	$\Delta Y/\Delta \phi$ -A	$\Delta Y/\Delta \theta$ -C	$\Delta Y/\Delta \psi$ -B	$\Delta Y/\Delta R$	$\Delta Y/\Delta \Theta$ -D	$\Delta Y/\Delta \Psi$ -E
	-1.00000	0.03491	-0.27925	0.00000	-0.24721	-0.28333	-1.00000	-0.00779	-0.00035
	$\Delta Z/\Delta R$	$\Delta Z/\Delta \Theta$ -D	$\Delta Z/\Delta \Psi$ -E	$\Delta Z/\Delta \phi$ -A	$\Delta Z/\Delta \theta$ -C	$\Delta Z/\Delta \psi$ -B	$\Delta Z/\Delta R$	$\Delta Z/\Delta \Theta$ -D	$\Delta Z/\Delta \Psi$ -E
	-0.00017	-99.80485	-6.24429	0.26734444	-99.47619	-6.22374	-0.00017	-0.06244	0.99805

GNSS+INS

Roll / Pitch = +0.03°
Heading = +0.336°
X, Y = +0.02m
Z = +0.03m

Coefficients of Position Vector P based on Initial Parameters:

	P[1,1]	P[2,1]	P[3,1]
	99.67100	-0.00500	0.28200
S:	99.67140		

Final Result for Laser Scan Point Coordinate and Uncertainty:

	X-Laser	Y-Laser	Z-Laser	dX-Laser
	-0.25736	-99.67069	0.26442	0.02679
S:	99.67137	0.07535	0.01625	0.04460

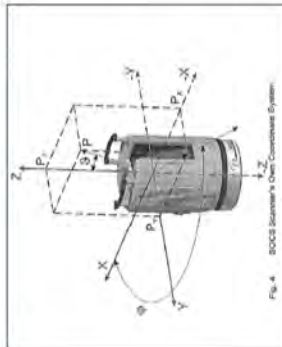


Fig. 4. BOCCA Scanner's Own Coordinate System

Appendix A-4

QPS QINSy Calibration Results

1st Calibration Procedure: Reiherstieg (Roll&Pitch), Suederelbe/Kattwyk (Heading)

1.1 Pitch calibration (Line 01402)			
area	subset	value [°]	remarks
GTH	1	3.50	excl roll, obj, Height=72m
GTH	2	3.52	excl roll, obj, Height=39m
GTH	3	3.51	excl roll, obj, Height=53m
GTH	4	3.52	excl roll, obj, Height=64m
GTH	5	3.51	excl roll, obj, Height=59m
GTH	6	3.53	excl roll, obj, Height=75m
	Mittelwert	3.515 °	
	StdDev	0.0096 °	

1.4 Pitch calibration (Line 01402)			
area	subset	value [°]	remarks
GTH	1	3.52	incl. roll+heading, obj, Height=72m
GTH	2	3.51	incl. roll+heading, obj, Height=40m
GTH	3	3.51	incl. roll+heading, obj, Height=53m
GTH	4	3.50	incl. roll+heading, obj, Height=53m
GTH	5	3.51	incl. roll+heading, obj, Height=59m
GTH	6	3.52	incl. roll+heading, obj, Height=78m
	Mittelwert	3.512 °	
	StdDev	0.0069 °	

1.2 Roll calibration (Line 01402)			
area	subset	value	remarks
GTH	1	0.08	incl. pitch, obj, Height=72m
GTH	2	0.08	incl. pitch, obj, Height=72m
GTH	3	0.08	incl. pitch, obj, Height=53m
GTH	4	0.07	incl. pitch, obj, Height=54m
GTH	5	0.07	incl. pitch, obj, Height=64m
GTH	6	0.07	incl. pitch, obj, Height=64m
GTH	7	0.07	incl. pitch, obj, Height=41m
GTH	8	0.06	incl. pitch, obj, Height=54m
GTH	9	0.07	incl. pitch, obj, Height=59m
GTH	10	0.07	incl. pitch, obj, Height=75m
	Mean	0.072 °	
	StdDev	0.0060 °	

Results 1st calibration

Roll [°]	0.072	0.0060
Pitch [°]	3.512	0.0069
Heading [°]	-0.280	0.0071

2nd Calibration Procedure: Waltershofer Hafen (Roll,Pitch&Heading), Parkhafen (Heading)

2.1 Pitch calibration (Line 06407 / 08-09)			
area	subset	value [°]	remarks
Predhikol	1	3.52	incl. roll+heading, obj, Height=85m
Predhikol	2	3.51	incl. roll+heading, obj, Height=86m
Predhikol	3	3.51	incl. roll+heading, obj, Height=86m
Predhikol	4	3.50	incl. roll+heading, obj, Height=86m
Predhikol	5	3.52	incl. roll+heading, obj, Height=84m
Predhikol	6	3.51	incl. roll+heading, obj, Height=91m
Predhikol	7	3.51	incl. roll+heading, obj, Height=102m
Predhikol	8	3.51	incl. roll+heading, obj, Height=88m
Predhikol	9	3.51	incl. roll+heading, obj, Height=86m
Predhikol	10	3.51	incl. roll+heading, obj, Height=65m
	Mittelwert	3.511 °	
	StdDev	0.0054 °	

2.2 Roll calibration (Line 06407 / 08-09)			
area	subset	value	remarks
Predhikol	1	0.04	incl. pitch, obj, Height=85m
Predhikol	2	0.05	incl. pitch, obj, Height=86m
Predhikol	3	0.05	incl. pitch, obj, Height=86m
Predhikol	4	0.06	incl. pitch, obj, Height=86m
Predhikol	5	0.05	incl. pitch, obj, Height=84m
Predhikol	6	0.04	incl. pitch, obj, Height=74m
Predhikol	7	0.05	incl. pitch, obj, Height=85m
Predhikol	8	0.05	incl. pitch, obj, Height=86m
Predhikol	9	0.04	incl. pitch, obj, Height=75m
Predhikol	10	0.04	incl. pitch, obj, Height=91m
	Mean	0.047 °	
	StdDev	0.0064 °	

Results 2nd calibration

Roll [°]	0.047	0.0064
Pitch [°]	3.511	0.0054
Heading [°]	-0.167	0.0106

Results 1st + 2nd calibration

Roll [°]	0.060	± 0.0088
Pitch [°]	3.511	± 0.0087
Heading [°]	-0.160	± 0.0128

QINSY Values

Roll [°]	-3.511
Pitch [°]	0.060
Heading [°]	265.810

1.3 Heading calibration (Line 02403+04)

area	subset	value	remarks
Kattwyk	1	-0.27	incl. roll+pitch, Dist.2Obj.= 20/250/400m
Kattwyk	2	-0.29	incl. roll+pitch, Dist.2Obj.= 100/330
Kattwyk	3	-0.28	incl. roll+pitch, Dist.2Obj.= 100/330
Kattwyk	4	-0.28	incl. roll+pitch, Dist.2Obj.= 125/355
	Mean	-0.280 °	
	StdDev	0.0071 °	

2.3 Heading calibration (Line 06408 / 07+09)

area	subset	value	remarks
Predhikol	1	-0.14	incl. roll+pitch, Dist.2Obj.= 50/25m
Predhikol	2	-0.15	incl. roll+pitch, Dist.2Obj.= 50/25m
Predhikol	3	-0.14	incl. roll+pitch, Dist.2Obj.= 50/25m
Predhikol	4	-0.15	incl. roll+pitch, Dist.2Obj.= 50/25m
Predhikol	5	-0.15	incl. roll+pitch, Dist.2Obj.= 50/25m
Predhikol	6	-0.16	incl. roll+pitch, Dist.2Obj.= 50/25m
Predhikol	7	-0.17	incl. roll+pitch, Dist.2Obj.= 50/25m
Predhikol	8	-0.16	incl. roll+pitch, Dist.2Obj.= 50/25m
Predhikol	9	-0.16	incl. roll+pitch, Dist.2Obj.= 50/25m
Predhikol	10	-0.16	incl. roll+pitch, Dist.2Obj.= 50/25m
	Mean	-0.154 °	
	StdDev	0.0092 °	

2.4 Heading calibration (Line 10411+12)

area	subset	value	remarks
Buka	1	-0.18	incl. roll+pitch, Dist.2Obj.= 35/25/250m
Buka	2	-0.19	incl. roll+pitch, Dist.2Obj.= 35/25/250m
Buka	3	-0.17	incl. roll+pitch, Dist.2Obj.= 65/55/280m
Buka	4	-0.18	incl. roll+pitch, Dist.2Obj.= 75/65/290m
Buka	5	-0.18	incl. roll+pitch, Dist.2Obj.= 45/35/260m
Buka	6	-0.18	incl. roll+pitch, Dist.2Obj.= 55/45/270m
Buka	7	-0.18	incl. roll+pitch, Dist.2Obj.= 65/55/280m
	Mean	-0.180 °	
	StdDev	0.0093 °	

Appendix A-5

RIEGL RiPROCESS Calibration Results – Scan Data Adjustment

Results Scan Data Adjustment – Computation 1

Scan Data Adjustment - Self Defined Plane Parameters

Plane-Parameter 1
 Min. plane inclination angle 25 deg
 Max. plane point deviation 0.05 m
 Min. plane point count 100
 Search radius 2 m
 Angular tolerance 1 deg
 Max. normal distance 0.25 m

1.Iteration													
line pair	match, Planes	Error/StdDev	Initial Roll	calc. Roll	calc. Change	calc. Confid.	Initial Pitch	calc. Pitch	calc. Change	calc. Confid.	Initial Yaw	calc. Yaw	calc. Change
0001+0004	376	0.0240	0.060	0.01701	-0.04299	0.00078	3.511	3.57483	0.16389	0.07292	0.190	0.16022	-0.02978
0002+0003	642	0.0170	0.060	0.02129	-0.03871	0.00051	3.511	3.56653	0.05553	0.01395	0.190	0.15016	-0.03984
0004+0005	506	0.0205	0.060	0.01291	-0.04709	0.00054	3.511	3.59055	0.07955	0.00398	0.190	0.13965	-0.05035
0003+0006	915	0.0163	0.060	0.02757	-0.03243	0.00048	3.511	3.55946	0.04846	0.00428	0.190	0.15000	-0.04000
0002+0007	715	0.0191	0.060	0.02872	-0.03128	0.00064	3.511	3.58402	0.07302	0.00807	0.190	0.16721	-0.02279
0006+0007	1121	0.0177	0.060	0.02688	-0.03312	0.00048	3.511	3.56030	0.04930	0.00475	0.190	0.19484	0.00484
0001+0008	583	0.0287	0.060	0.02727	-0.03273	0.00107	3.511	3.60349	0.09249	0.01246	0.190	0.19368	0.00368
0005+0008	882	0.0181	0.060	0.02379	-0.03621	0.00051	3.511	3.56780	0.05680	0.00288	0.190	0.15100	-0.15987
2+3+6+7	5273	0.0181	0.060	0.02526	-0.03474	0.00021	3.511	3.56059	0.04959	0.00280	0.190	0.15100	-0.03900
1+4+5+8	3563	0.0245	0.060	0.01641	-0.04359	0.00026	3.511	3.57963	0.06863	0.00282	0.190	0.15749	-0.03251
Mean Value		0.0204		0.02221				3.58473				0.16269	

2.Iteration													
line pair	match, Planes	Error/StdDev	Initial Roll	calc. Roll	calc. Change	calc. Confid.	Initial Pitch	calc. Pitch	calc. Change	calc. Confid.	Initial Yaw	calc. Yaw	calc. Change
0001+0004	434	0.0178	0.0227	0.01598	-0.00672	0.00055	3.5847	3.60924	0.02454	0.05050	0.1627	0.15783	-0.00486
0002+0003	845	0.0153	0.0227	0.01856	-0.00414	0.00035	3.5847	3.59500	0.01030	0.01073	0.1627	0.14842	-0.01428
0004+0005	604	0.0234	0.0227	0.01649	-0.00621	0.00059	3.5847	3.59444	0.00974	0.00468	0.1627	0.14540	-0.0173
0003+0006	1077	0.0154	0.0227	0.02501	0.00231	0.00038	3.5847	3.56723	-0.01747	0.00367	0.1627	0.14924	-0.01346
0002+0007	993	0.0170	0.0227	0.02449	0.00179	0.00042	3.5847	3.57695	-0.00775	0.00631	0.1627	0.16384	0.00114
0006+0007	1414	0.0174	0.0227	0.02390	0.0012	0.00040	3.5847	3.56293	-0.02177	0.00469	0.1627	0.19714	0.03444
0001+0008	680	0.0308	0.0227	0.02792	0.00522	0.00106	3.5847	3.60488	0.02018	0.01182	0.1627	0.19420	0.0315
0005+0008	1100	0.0184	0.0227	0.02360	0.00099	0.00045	3.5847	3.56914	-0.01556	0.00249	0.1627	0.15080	-0.11837
2+3+6+7	6283	0.0167	0.0227	0.02336	0.00066	0.00017	3.5847	3.56688	-0.01782	0.00242	0.1627	0.15080	-0.01190
1+4+5+8	4015	0.0246	0.0227	0.01582	-0.00688	0.00024	3.5847	3.57919	-0.00551	0.00259	0.1627	0.15757	-0.00513
1+4+5	1706	0.0243	0.0227	0.02072	-0.00688	0.00044	3.5847	3.58755	-0.00551	0.00464	0.1627	0.15950	-0.00513
4+5+8	2231	0.0207	0.0227	0.01613	-0.00657	0.00028	3.5847	3.58066	-0.00404	0.00229	0.1627	0.13715	-0.02555
Mean Value		0.0202		0.02100				3.58284				0.16010	

Results Scan Data Adjustment – Computation 2

Scan Data Adjustment - Default Plane Parameters

Plane-Parameter 2 (Default Mobile Laser Scanning)
 Min. plane inclination angle 0 deg
 Max. plane point deviation 0.03 m
 Min. plane point count 100

Search radius 5 m
 Angular tolerance 1 deg
 Max. normal distance 0.10 m

1.Iteration														
line pair	match. Planes	Error/StdDev.	Initial Roll	calc. Roll	calc. Change	calc. Confid.	Initial Pitch	calc. Pitch	calc. Change	calc. Confid.	Initial Yaw	calc. Yaw	calc. Change	calc. Confid.
0001+0004	288	0.0220	0.060	0.02210	-0.03790	0.00105	3.511	3.61243	0.10143	0.05869	0.190	0.16158	-0.02842	0.00211
0002+0003	625	0.0255	0.060	0.02274	-0.03726	0.00071	3.511	3.59342	0.08242	0.02035	0.190	0.15443	-0.03557	0.00182
0004+0005	364	0.0216	0.060	0.01751	-0.04249	0.00072	3.511	3.59396	0.08296	0.00449	0.190	0.13816	-0.05184	0.00323
0003+0006	883	0.0245	0.060	0.03030	-0.02970	0.00073	3.511	3.55647	0.04547	0.00476	0.190	0.15557	-0.03443	0.00241
0002+0007	663	0.0247	0.060	0.03578	-0.02422	0.00096	3.511	3.57585	0.06485	0.00876	0.190	0.17393	-0.01607	0.00302
0006+0007	1005	0.0212	0.060	0.03347	-0.02653	0.00059	3.511	3.56913	0.05813	0.00897	0.190	0.17709	-0.01291	0.00556
0001+0008	405	0.0229	0.060	0.03574	-0.02426	0.00108	3.511	3.58129	0.07029	0.00799	0.190	0.20383	0.01383	0.00349
0005+0008	561	0.0234	0.060	0.03223	-0.02777	0.00078	3.511	3.56455	0.05355	0.00553	0.190	0.15619	-0.13540	0.00336
2+3+6+7	4897	0.0238	0.060	0.03030	-0.02970	0.00030	3.511	3.55831	0.04731	0.00275	0.190	0.15619	-0.03381	0.00100
1+4+5+8	2493	0.0238	0.060	0.02690	-0.03310	0.00037	3.511	3.56081	0.04981	0.00273	0.190	0.16156	-0.02844	0.00131
Mean Value		0.0233		0.02871				3.575622						0.16470

2.Iteration														
line pair	match. Planes	Error/StdDev.	Initial Roll	calc. Roll	calc. Change	calc. Confid.	Initial Pitch	calc. Pitch	calc. Change	calc. Confid.	Initial Yaw	calc. Yaw	calc. Change	calc. Confid.
0001+0004	321	0.0217	0.0287	0.01873	-0.00997	0.00079	3.5766	3.63576	0.05916	0.05441	0.1647	0.15804	-0.00666	0.00194
0002+0003	796	0.0215	0.0287	0.01945	-0.00925	0.00048	3.5766	3.59128	0.01468	0.01690	0.1647	0.14976	-0.01494	0.00133
0004+0005	411	0.0208	0.0287	0.01733	-0.01637	0.00051	3.5766	3.60551	0.02891	0.00400	0.1647	0.13643	-0.02827	0.00283
0003+0006	966	0.0211	0.0287	0.02517	-0.00353	0.00053	3.5766	3.56717	-0.00943	0.00389	0.1647	0.14822	-0.01648	0.00204
0002+0007	898	0.0220	0.0287	0.02559	-0.00211	0.00061	3.5766	3.58113	0.00453	0.00597	0.1647	0.16717	0.00247	0.00218
0006+0007	1163	0.0175	0.0287	0.02959	0.00089	0.00042	3.5766	3.56840	-0.00820	0.00664	0.1647	0.18640	0.0217	0.00471
0001+0008	476	0.0204	0.0287	0.02844	-0.00026	0.00072	3.5766	3.57772	0.00112	0.00567	0.1647	0.20351	0.03881	0.00277
0005+0008	690	0.0222	0.0287	0.02583	-0.00287	0.00058	3.5766	3.56906	-0.00754	0.00382	0.1647	0.15173	-0.11083	0.00291
2+3+6+7	5576	0.0216	0.0287	0.02541	-0.00329	0.00023	3.5766	3.56541	-0.01119	0.00232	0.1647	0.15173	-0.01297	0.00082
1+4+5+8	2740	0.0230	0.0287	0.02266	-0.00688	0.00029	3.5766	3.56896	-0.00551	0.00230	0.1647	0.16093	-0.00513	0.00120
1+4+5	1206	0.0214	0.0287	0.01851	-0.00688	0.00038	3.5766	3.58280	-0.00551	0.00343	0.1647	0.16041	-0.00513	0.00133
4+5+8	1482	0.0229	0.0287	0.02194	-0.00676	0.00041	3.5766	3.57472	-0.00188	0.00271	0.1647	0.13675	-0.02795	0.00205
Mean Value		0.0213		0.02289				3.58233					0.15994	

Results Scan Data Adjustment – Final Result

Determination of the final Angular Misalignments by Averaging:

	QINSy	RiPro - 1.1	RiPro - 1.2	RiPro - 2.1	RiPro - 2.2	Mittelwert
Rolloffset	0.060	0.0227	0.0210	0.0287	0.0229	0.0219
Pitchoffset	3.511	3.5847	3.5828	3.5766	3.5823	3.5826
Yawoffset	0.190	0.1627	0.1601	0.1647	0.1599	0.1600
Plane StdDev	-	0.0204	0.0202	0.0233	0.0213	-

Final Evaluation of Determined Angular Misalignments (see following Reports) :

line pair	match. Planes	Error/StdDev.	Final Roll	final Pitch	final Yaw
0001+0004	327	0.0208	0.0219	3.5826	0.1600
0002+0003	808	0.0220	0.0219	3.5826	0.1600
0004+0005	428	0.0214	0.0219	3.5826	0.1600
0003+0006	973	0.0216	0.0219	3.5826	0.1600
0002+0007	896	0.0230	0.0219	3.5826	0.1600
0006+0007	1147	0.0197	0.0219	3.5826	0.1600
0001+0008	461	0.0247	0.0219	3.5826	0.1600
0005+0008	586	0.0213	0.0219	3.5826	0.1600
2+3+6+7	5594	0.0220	0.0219	3.5826	0.1600
1+4+5+8	2742	0.0228	0.0219	3.5826	0.1600
Mean Value		0.0219			

Plane-Parameter (Default Mobile Laser Scanning)

Min. plane inclination angle

0 deg

0.03 m

100

Max. plane point deviation

0.03 m

100

Min. plane point count

0.03 m

100

Search radius

5 m

1 deg

0.10 m

Angular tolerance

5 m

1 deg

0.10 m

Max. normal distance

5 m

1 deg

0.10 m

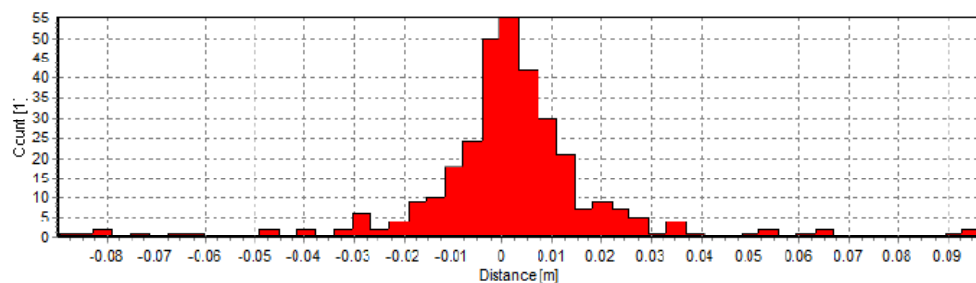
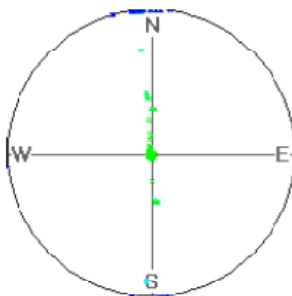
Evaluation of Scan Data Adjustment

RiPROCESS Report – Lines 1+4

RiPROCESS Scan Data Adjustment Protocol							
Project:				Grasbrook-RiProcess			
Protocol date:				2010-12-30 19:24			
Operator:				Thomas Thies			
Comments:							
Program version:				RiPROCESS v1.4.5 (2010-09-22)			
Computer:				THOMASTHIES-PC			
Physical units:				m, deg			
Observation parameters							
Calculation parameters							
Calculation mode:				Adjustment			
Calculation time:				135 msecs			
Calculation mode:				Least Square Fit			
Tolerance:				0.010000			
Search corresp. planes:				False			
Search radius [m]:				1.000			
Angular tolerance [deg]:				5.000			
Max. normal dist. [m]:				1.000			
Observations active:				True			
Observations count:				327			
Calculation results							
Number of free parameters:				0			
Number of observations:				327			
Error (Std. deviation) [m]:				0.0208			
Laser devices							
Name	Roll	Pitch	Yaw	X	Y	Z	Range Shift
Scanner 1 (VZ-400,)	0.02190	3.58260	0.16000	0.000	0.000	0.000	0.0000
- Confidence	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
Observations							
Best 15 observations							
#	Object 1	Object 2	Deviation	Description			
1	100812_105024	100812_110414	0.000				
2	100812_105024	100812_110414	0.000				
3	100812_105024	100812_110414	0.000				
4	100812_105024	100812_110414	0.000				
5	100812_105024	100812_110414	0.000				
6	100812_105024	100812_110414	0.000				
7	100812_105024	100812_110414	0.000				
8	100812_105024	100812_110414	0.000				
9	100812_105024	100812_110414	0.000				
10	100812_105024	100812_110414	0.000				
11	100812_105024	100812_110414	0.000				
12	100812_105024	100812_110414	0.000				
13	100812_105024	100812_110414	0.000				
14	100812_105024	100812_110414	0.000				
15	100812_105024	100812_110414	0.000				

RiPROCESS Report – Lines 1+4

Worst 15 observations				
#	Object 1	Object 2	Deviation	Description
1	100812_105024	100812_110414	0.095	
2	100812_105024	100812_110414	0.094	
3	100812_105024	100812_110414	0.090	
4	100812_105024	100812_110414	-0.088	
5	100812_105024	100812_110414	-0.083	
6	100812_105024	100812_110414	-0.082	
7	100812_105024	100812_110414	-0.081	
8	100812_105024	100812_110414	-0.073	
9	100812_105024	100812_110414	-0.067	
10	100812_105024	100812_110414	0.066	
11	100812_105024	100812_110414	0.064	
12	100812_105024	100812_110414	0.063	
13	100812_105024	100812_110414	-0.061	
14	100812_105024	100812_110414	0.054	
15	100812_105024	100812_110414	0.053	
Best 2 scans				
Name		Objects	Std. dev.	
100812_110414		327	0.021	
100812_105024		327	0.021	
Worst 2 scans				
Name		Objects	Std. dev.	
100812_105024		327	0.021	
100812_110414		327	0.021	

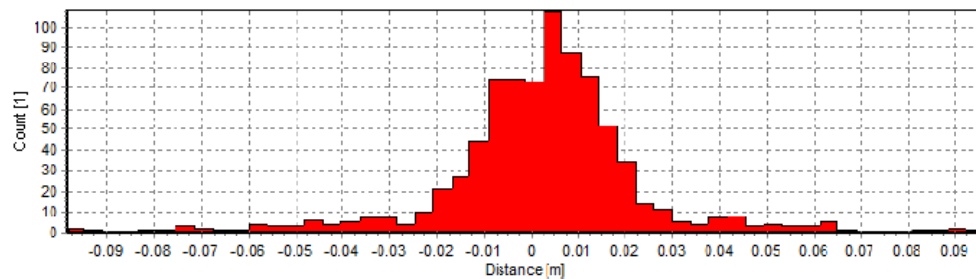
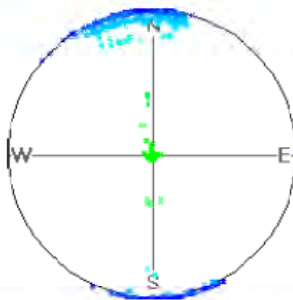
Histogram of residues**Orientation chart**

RiPROCESS Report – Lines 2+3

RiPROCESS Scan Data Adjustment Protocol							
Project:				Grasbrook-RiProcess			
Protocol date:				2010-12-30 19:25			
Operator:				Thomas Thues			
Comments:							
Program version:				RiPROCESS v1.4.5 (2010-09-22)			
Computer:				THOMASTHUES-PC			
Physical units:				m, deg			
Observation parameters							
Calculation parameters							
Calculation mode:				Adjustment			
Calculation time:				276 msec			
Calculation mode:				Least Square Fit			
Tolerance:				0.010000			
Search corresp. planes:				False			
Search radius: [m]:				1.000			
Angular tolerance [deg]:				5.000			
Max. normal dist. [m]:				1.000			
Observations active:				True			
Observations count:				808			
Calculation results							
Number of free parameters:				0			
Number of observations:				808			
Error (Std. deviation) [m]:				0.0217			
Laser devices							
Name	Roll	Pitch	Yaw	X	Y	Z	Range Shift
Scanner 1 (VZ-400,)	0.02190	3.58260	0.16000	0.000	0.000	0.000	0.0000
- Confidence	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
Observations							
Best 15 observations							
#	Object 1	Object 2	Deviation	Description			
1	100812_105504	100812_105920	0.000				
2	100812_105504	100812_105920	0.000				
3	100812_105504	100812_105920	0.000				
4	100812_105504	100812_105920	0.000				
5	100812_105504	100812_105920	0.000				
6	100812_105504	100812_105920	0.000				
7	100812_105504	100812_105920	0.000				
8	100812_105504	100812_105920	0.000				
9	100812_105504	100812_105920	0.000				
10	100812_105504	100812_105920	0.000				
11	100812_105504	100812_105920	0.000				
12	100812_105504	100812_105920	0.000				
13	100812_105504	100812_105920	0.000				
14	100812_105504	100812_105920	0.000				
15	100812_105504	100812_105920	0.000				

RiPROCESS Report – Lines 2+3

Worst 15 observations				
#	Object 1	Object 2	Deviation	Description
1	100812_105504	100812_105920	-0.097	
2	100812_105504	100812_105920	-0.095	
3	100812_105504	100812_105920	0.095	
4	100812_105504	100812_105920	-0.093	
5	100812_105504	100812_105920	0.092	
6	100812_105504	100812_105920	0.089	
7	100812_105504	100812_105920	0.087	
8	100812_105504	100812_105920	0.085	
9	100812_105504	100812_105920	-0.082	
10	100812_105504	100812_105920	0.079	
11	100812_105504	100812_105920	-0.073	
12	100812_105504	100812_105920	-0.072	
13	100812_105504	100812_105920	0.072	
14	100812_105504	100812_105920	-0.069	
15	100812_105504	100812_105920	-0.068	
Best 2 scans				
Name		Objects	Std. dev.	
100812_105920		808	0.022	
100812_105504		808	0.022	
Worst 2 scans				
Name		Objects	Std. dev.	
100812_105504		808	0.022	
100812_105920		808	0.022	

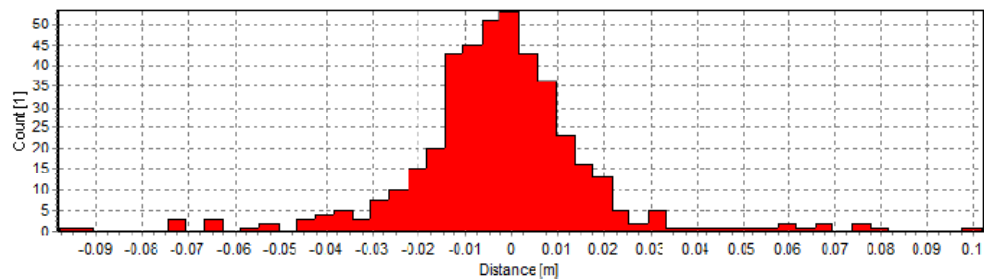
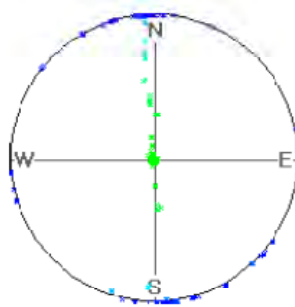
Histogram of residues**Orientation chart**

RiPROCESS Report – Lines 4+5

RiPROCESS Scan Data Adjustment Protocol							
Project:				Grasbrook-RiProcess			
Protocol date:				2010-12-30 19:27			
Operator:				Thomas Thies			
Comments:							
Program version:				RiPROCESS v1.4.5 (2010-09-22)			
Computer:				THOMASTHIES-PC			
Physical units:				m, deg			
Observation parameters							
Calculation parameters							
Calculation mode:				Adjustment			
Calculation time:				1/4 msecs			
Calculation mode:				Least Square Fit			
Tolerance:				0.01(0000			
Search corresp. planes:				False			
Search radius [m]:				1.000			
Angular tolerance [deg]:				5.000			
Max. normal dist. [m]:				1.000			
Observations active:				True			
Observations count:				428			
Calculation results							
Number of free parameters:				0			
Number of observations:				428			
Error (Std. deviation) [m]:				0.0214			
Laser devices							
Name	Roll	Pitch	Yaw	X	Y	Z	Range Shift
Scanner 1 (VZ-400,)	0.02190	3.58260	0.16000	0.000	0.000	0.000	0.0000
- Confidence	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
Observations							
Best 15 observations							
#	Object 1	Object 2	Deviation	Description			
1	100812_110414	100812_110736	0.000				
2	100812_110414	100812_110736	0.000				
3	100812_110414	100812_110736	0.000				
4	100812_110414	100812_110736	0.000				
5	100812_110414	100812_110736	0.000				
6	100812_110414	100812_110736	0.000				
7	100812_110414	100812_110736	0.000				
8	100812_110414	100812_110736	0.000				
9	100812_110414	100812_110736	0.000				
10	100812_110414	100812_110736	0.000				
11	100812_110414	100812_110736	0.001				
12	100812_110414	100812_110736	0.001				
13	100812_110414	100812_110736	0.001				
14	100812_110414	100812_110736	0.001				
15	100812_110414	100812_110736	-0.001				

RiPROCESS Report – Lines 4+5

Worst 15 observations				
#	Object 1	Object 2	Deviation	Description
1	100812_110414	100812_110736	0.100	
2	100812_110414	100812_110736	0.096	
3	100812_110414	100812_110736	-0.092	
4	100812_110414	100812_110736	0.080	
5	100812_110414	100812_110736	0.078	
6	100812_110414	100812_110736	0.074	
7	100812_110414	100812_110736	-0.072	
8	100812_110414	100812_110736	-0.072	
9	100812_110414	100812_110736	-0.071	
10	100812_110414	100812_110736	0.067	
11	100812_110414	100812_110736	0.067	
12	100812_110414	100812_110736	-0.066	
13	100812_110414	100812_110736	0.066	
14	100812_110414	100812_110736	-0.064	
15	100812_110414	100812_110736	-0.063	
Best 2 scans				
Name		Objects	Std. dev.	
100812_110736		478	0.071	
100812_110414		428	0.021	
Worst 2 scans				
Name		Objects	Std. dev.	
100812_110414		428	0.021	
100812_110736		428	0.021	

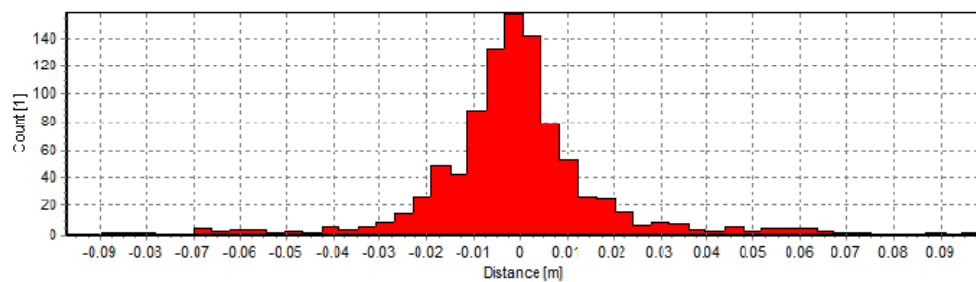
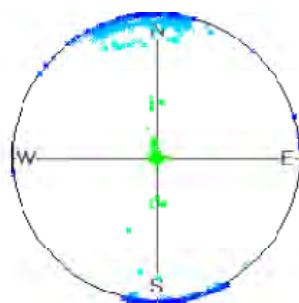
Histogram of residues**Orientation chart**

RiPROCESS Report – Lines 3+6

RiPROCESS Scan Data Adjustment Protocol							
Project:				Grasbrook-RiProcess			
Protocol date:				2010-12-30 19:29			
Operator:				Thomas Thies			
Comments:							
Program version:				RiPROCESS v1.4.5 (2010-09-22)			
Computer:				THOMASTHIES-PC			
Physical units:				m, deg			
Observation parameters							
Calculation parameters							
Calculation mode:				Adjustment			
Calculation time:				300 msec			
Calculation mode:				Least Square Fit			
Tolerance:				0.01(000)			
Search corresp. planes:				False			
Search radius [m]:				1.000			
Angular tolerance [deg]:				5.000			
Max. normal dist. [m]:				1.000			
Observations active:				True			
Observations count:				973			
Calculation results							
Number of free parameters:				0			
Number of observations:				973			
Error (Std. deviation) [m]:				0.0216			
Laser devices							
Name	Roll	Pitch	Yaw	X	Y	Z	Range Shift
Scanner 1 (VZ-400,)	0.02190	3.58260	0.16000	0.000	0.000	0.000	0.0000
- Confidence	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
Observations							
Best 15 observations							
#	Object 1	Object 2	Deviation	Description			
1	100812_105920	100812_111226	0.000				
2	100812_105920	100812_111226	0.000				
3	100812_105920	100812_111226	0.000				
4	100812_105920	100812_111226	0.000				
5	100812_105920	100812_111226	0.000				
6	100812_105920	100812_111226	0.000				
7	100812_105920	100812_111226	0.000				
8	100812_105920	100812_111226	0.000				
9	100812_105920	100812_111226	0.000				
10	100812_105920	100812_111226	0.000				
11	100812_105920	100812_111226	0.000				
12	100812_105920	100812_111226	0.000				
13	100812_105920	100812_111226	0.000				
14	100812_105920	100812_111226	0.000				
15	100812_105920	100812_111226	0.000				

RiPROCESS Report – Lines 3+6

Worst 15 observations				
#	Object 1	Object 2	Deviation	Description
1	100812_105920	100812_111226	0.097	
2	100812_105920	100812_111226	0.097	
3	100812_105920	100812_111226	-0.095	
4	100812_105920	100812_111226	0.094	
5	100812_105920	100812_111226	0.090	
6	100812_105920	100812_111226	-0.087	
7	100812_105920	100812_111226	0.087	
8	100812_105920	100812_111226	-0.087	
9	100812_105920	100812_111226	0.086	
10	100812_105920	100812_111226	-0.083	
11	100812_105920	100812_111226	-0.083	
12	100812_105920	100812_111226	0.082	
13	100812_105920	100812_111226	-0.080	
14	100812_105920	100812_111226	-0.079	
15	100812_105920	100812_111226	0.077	
Best 2 scans				
Name		Objects	Std. dev.	
100812_111226		973	0.022	
100812_105920		973	0.022	
Worst 2 scans				
Name		Objects	Std. dev.	
100812_105920		973	0.022	
100812_111226		973	0.022	

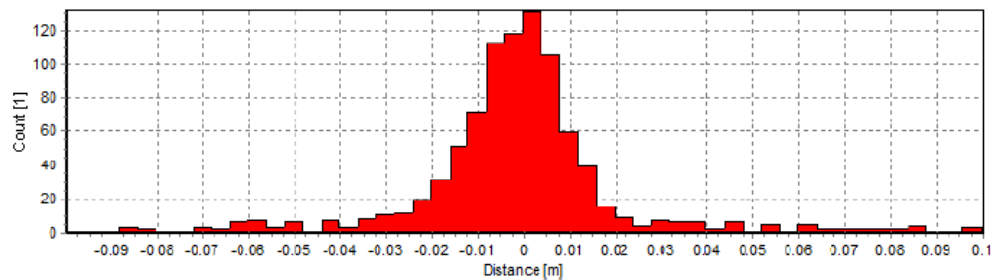
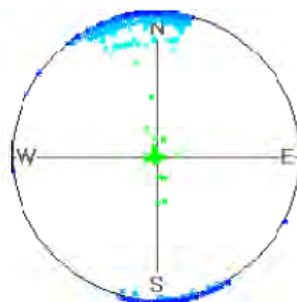
Histogram of residues**Orientation chart**

RiPROCESS Report – Lines 2+7

RiPROCESS Scan Data Adjustment Protocol								
Project:				Grasbrook-RiProcess				
Protocol date:				2010-12-30 19:31				
Operator:				Thomas Thies				
Comments:								
Program version:				RiPROCESS v1.4.5 (2010-09-22)				
Computer:				THOMASTHIES-PC				
Physical units:				m, deg				
Observation parameters								
Calculation parameters								
Calculation mode:				Adjustment				
Calculation time:				304 msec				
Calculation mode:				Least Square Fit				
Tolerance:				0.010000				
Search corresp. planes:				False				
Search radius [m]:				1.000				
Angular tolerance [deg]:				5.000				
Max. normal dist. [m]:				1.000				
Observations active:				True				
Observations count:				896				
Calculation results								
Number of free parameters:				0				
Number of observations:				896				
Error (Std. deviation) [m]:				0.0230				
Laser devices								
Name		Roll	Pitch	Yaw	X	Y	Z	Range Shift
Scanner 1 (VZ-400,)		0.02190	3.58260	0.16000	0.000	0.000	0.000	0.0000
- Confidence		0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
Observations								
Best 15 observations								
#	Object 1		Object 2		Deviation		Description	
1	100812_105504		100812_111623		0.000			
2	100812_105504		100812_111623		0.000			
3	100812_105504		100812_111623		0.000			
4	100812_105504		100812_111623		0.000			
5	100812_105504		100812_111623		0.000			
6	100812_105504		100812_111623		0.000			
7	100812_105504		100812_111623		0.000			
8	100812_105504		100812_111623		0.000			
9	100812_105504		100812_111623		0.000			
10	100812_105504		100812_111623		0.000			
11	100812_105504		100812_111623		0.000			
12	100812_105504		100812_111623		0.000			
13	100812_105504		100812_111623		0.000			
14	100812_105504		100812_111623		0.000			
15	100812_105504		100812_111623		0.000			

RiPROCESS Report – Lines 2+7

Worst 15 observations					
#	Object 1		Object 2	Deviation	Description
1	100812_105504		100812_111623	-0.098	
2	100812_105504		100812_111623	0.098	
3	100812_105504		100812_111623	0.097	
4	100812_105504		100812_111623	0.096	
5	100812_105504		100812_111623	-0.094	
6	100812_105504		100812_111623	0.093	
7	100812_105504		100812_111623	-0.091	
8	100812_105504		100812_111623	0.087	
9	100812_105504		100812_111623	-0.086	
10	100812_105504		100812_111623	0.086	
11	100812_105504		100812_111623	0.085	
12	100812_105504		100812_111623	-0.085	
13	100812_105504		100812_111623	-0.085	
14	100812_105504		100812_111623	0.085	
15	100812_105504		100812_111623	-0.084	
Best 2 scans					
Name			Objects	Std. dev.	
100812_111623			896	0.023	
100812_105504			896	0.023	
Worst 2 scans					
Name			Objects	Std. dev.	
100812_105504			896	0.023	
100812_111623			896	0.023	

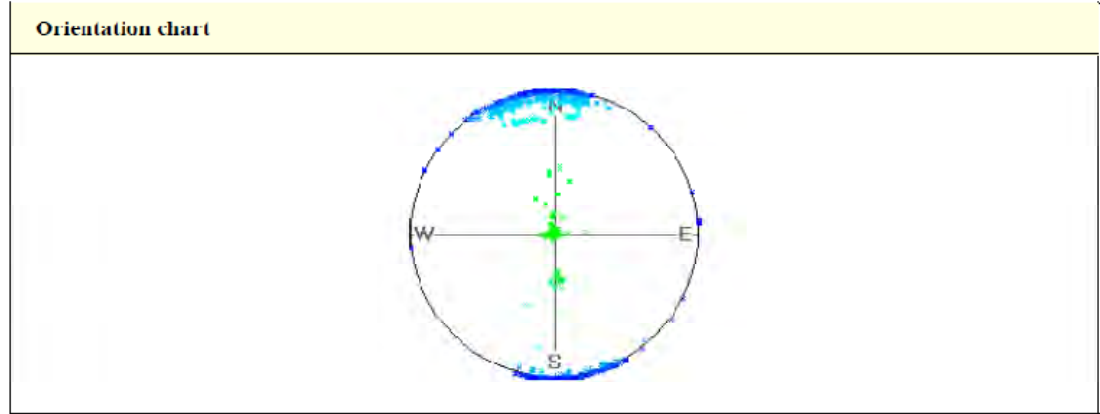
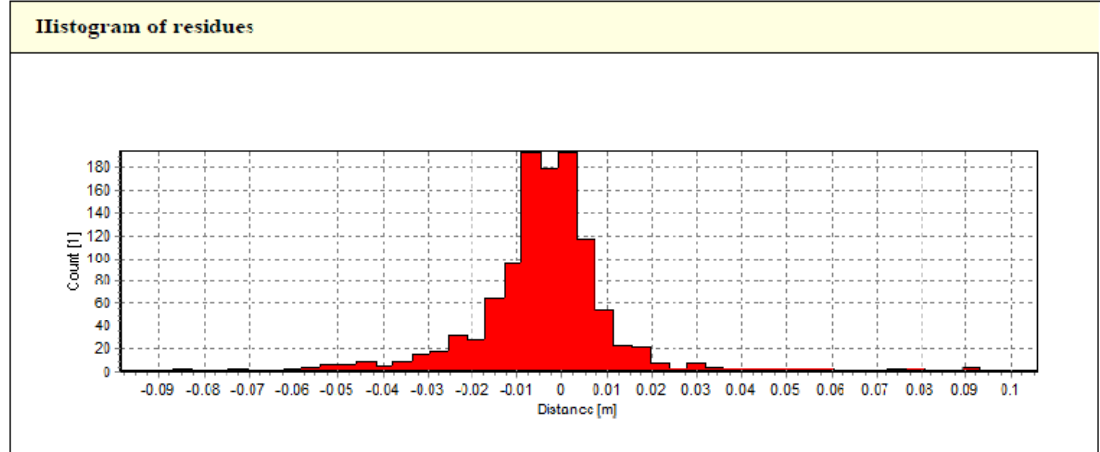
Histogram of residues**Orientation chart**

RiPROCESS Report – Lines 6+7

RiPROCESS Scan Data Adjustment Protocol							
Project:				Grasbrook-RiProcess			
Protocol date:				2010-12-30 19:32			
Operator:				Thomas Thies			
Comments:							
Program version:				RiPROCESS v1.4.5 (2010-09-22)			
Computer:				THOMASTHIES-PC			
Physical units:				m, deg			
Observation parameters							
Calculation parameters							
Calculation mode:				Adjustment			
Calculation time:				350 msecs			
Calculation mode:				Least Square Fit			
Tolerance:				0.010000			
Search corresp. planes:				False			
Search radius [m]:				1.000			
Angular tolerance [deg]:				5.000			
Max. normal dist. [m]:				1.000			
Observations active:				True			
Observations count:				1147			
Calculation results							
Number of free parameters:				0			
Number of observations:				1147			
Error (Std. deviation) [m]:				0.0197			
Laser devices							
Name	Roll	Pitch	Yaw	X	Y	Z	Range Shift
Scanner 1 (VZ-400,)	0.02190	3.58260	0.16000	0.000	0.000	0.000	0.0000
- Confidence	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
Observations							
Best 15 observations							
#	Object 1	Object 2	Deviation	Description			
1	100812_111226	100812_111623	0.000				
2	100812_111226	100812_111623	0.000				
3	100812_111226	100812_111623	0.000				
4	100812_111226	100812_111623	0.000				
5	100812_111226	100812_111623	0.000				
6	100812_111226	100812_111623	0.000				
7	100812_111226	100812_111623	0.000				
8	100812_111226	100812_111623	0.000				
9	100812_111226	100812_111623	0.000				
10	100812_111226	100812_111623	0.000				
11	100812_111226	100812_111623	0.000				
12	100812_111226	100812_111623	0.000				
13	100812_111226	100812_111623	0.000				
14	100812_111226	100812_111623	0.000				
15	100812_111226	100812_111623	0.000				

RiPROCESS Report – Lines 6+7

Worst 15 observations				
#	Object 1	Object 2	Deviation	Description
1	100812_111226	100812_111623	0.104	
2	100812_111226	100812_111623	-0.097	
3	100812_111226	100812_111623	0.093	
4	100812_111226	100812_111623	0.093	
5	100812_111226	100812_111623	0.092	
6	100812_111226	100812_111623	0.091	
7	100812_111226	100812_111623	-0.091	
8	100812_111226	100812_111623	0.090	
9	100812_111226	100812_111623	-0.088	
10	100812_111226	100812_111623	0.087	
11	100812_111226	100812_111623	0.085	
12	100812_111226	100812_111623	-0.085	
13	100812_111226	100812_111623	-0.083	
14	100812_111226	100812_111623	0.079	
15	100812_111226	100812_111623	0.079	
Best 2 scans				
Name		Objects	Std. dev.	
100812_111623		1147	0.019	
100812_111226		1147	0.019	
Worst 2 scans				
Name		Objects	Std. dev.	
100812_111226		1147	0.019	
100812_111623		1147	0.019	

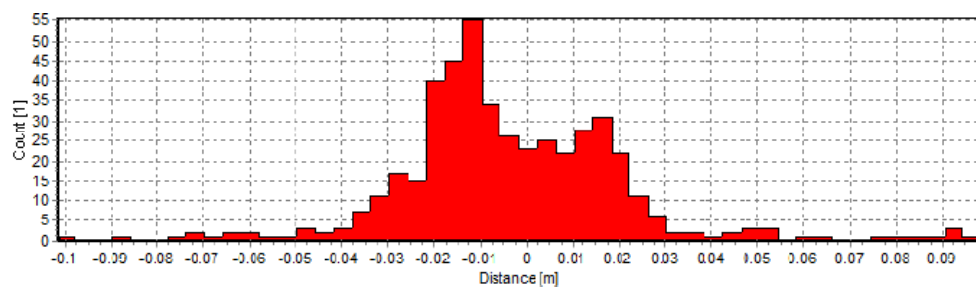
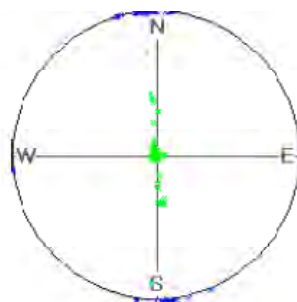


RiPROCESS Report – Lines 1+8

RiPROCESS Scan Data Adjustment Protocol								
Project:				Grasbrook-RiProcess				
Protocol date:				2010-12-30 19:35				
Operator:				Thomas Thies				
Comments:								
Program version:				RiPROCESS v1.4.5 (2010-09-22)				
Computer:				THOMASTHIES-PC				
Physical units:				m, deg				
Observation parameters								
Calculation parameters								
Calculation mode:				Adjustment				
Calculation time:				191 msec				
Calculation mode:				Least Square Fit				
Tolerance:				0.010000				
Search corresp. planes:				False				
Search radius [m]:				1.000				
Angular tolerance [deg]:				5.000				
Max. normal dist. [m]:				1.000				
Observations active:				True				
Observations count:				461				
Calculation results								
Number of free parameters:				0				
Number of observations:				461				
Error (Std. deviation) [m]:				0.0247				
Laser devices								
Name		Koll	Pitch	Yaw	X	Y	Z	Range Shift
Scanner 1 (VZ-400,)		0.02190	3.58260	0.16000	0.000	0.000	0.000	0.0000
- Confidence		0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
Observations								
Best 15 observations								
#	Object 1		Object 2		Deviation		Description	
1	100812_105024		100812_112126		0.000			
2	100812_105024		100812_112126		0.000			
3	100812_105024		100812_112126		0.000			
4	100812_105024		100812_112126		0.000			
5	100812_105024		100812_112126		0.001			
6	100812_105024		100812_112126		0.001			
7	100812_105024		100812_112126		0.001			
8	100812_105024		100812_112126		-0.001			
9	100812_105024		100812_112126		0.001			
10	100812_105024		100812_112126		-0.001			
11	100812_105024		100812_112126		-0.001			
12	100812_105024		100812_112126		-0.001			
13	100812_105024		100812_112126		0.001			
14	100812_105024		100812_112126		-0.001			
15	100812_105024		100812_112126		-0.001			

RiPROCESS Report – Lines 1+8

Worst 15 observations					
#	Object 1		Object 2	Deviation	Description
1	100812_105024		100812_112126	-0.100	
2	100812_105024		100812_112126	0.097	
3	100812_105024		100812_112126	0.095	
4	100812_105024		100812_112126	0.092	
5	100812_105024		100812_112126	0.091	
6	100812_105024		100812_112126	0.090	
7	100812_105024		100812_112126	-0.088	
8	100812_105024		100812_112126	0.086	
9	100812_105024		100812_112126	0.081	
10	100812_105024		100812_112126	0.079	
11	100812_105024		100812_112126	-0.074	
12	100812_105024		100812_112126	-0.072	
13	100812_105024		100812_112126	-0.070	
14	100812_105024		100812_112126	-0.067	
15	100812_105024		100812_112126	0.063	
Best 2 scans					
Name			Objects	Std. dev.	
100812_112126			461	0.024	
100812_105024			461	0.024	
Worst 2 scans					
Name			Objects	Std. dev.	
100812_105024			461	0.024	
100812_112126			461	0.024	

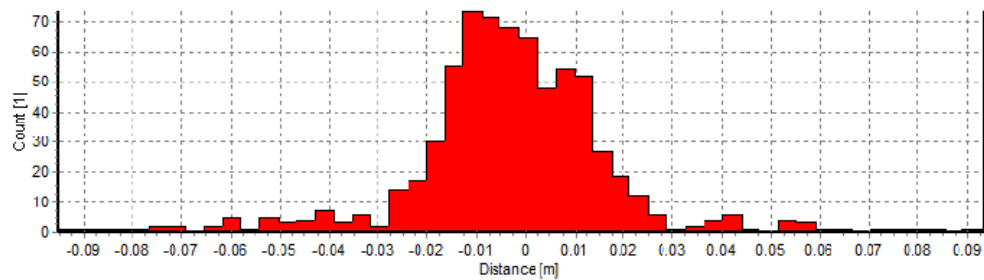
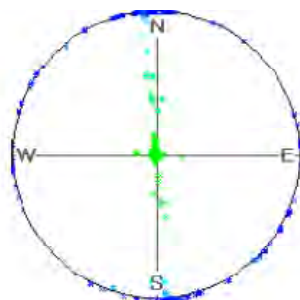
Histogram of residues**Orientation chart**

RiPROCESS Report – Lines 5+8

RiPROCESS Scan Data Adjustment Protocol							
Project:				Grasbrook-RiProcess			
Protocol date:				2010-12-30 19:36			
Operator:				Thomas Thies			
Comments:							
Program version:				RiPROCESS v1.4.5 (2010-09-22)			
Computer:				THOMASTHIES-PC			
Physical units:				m, deg			
Observation parameters							
Calculation parameters							
Calculation mode:				Adjustment			
Calculation time:				251 msec			
Calculation mode:				Least Square Fit			
Tolerance:				0.010000			
Search corresp. planes:				False			
Search radius [m]:				1.000			
Angular tolerance [deg]:				5.000			
Max. normal dist. [m]:				1.000			
Observations active:				True			
Observations count:				686			
Calculation results							
Number of free parameters:				0			
Number of observations:				686			
Error (Std. deviation) [m]:				0.0213			
Laser devices							
Name	Roll	Pitch	Yaw	X	Y	Z	Range Shift
Scanner 1 (VZ-400,)	0.02190	3.58260	0.16000	0.000	0.000	0.000	0.0000
- Confidence	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
Observations							
Best 15 observations							
#	Object 1	Object 2	Deviation	Description			
1	100812_110736	100812_112126	0.000				
2	100812_110736	100812_112126	0.000				
3	100812_110736	100812_112126	0.000				
4	100812_110736	100812_112126	0.000				
5	100812_110736	100812_112126	0.000				
6	100812_110736	100812_112126	0.000				
7	100812_110736	100812_112126	0.000				
8	100812_110736	100812_112126	0.000				
9	100812_110736	100812_112126	0.000				
10	100812_110736	100812_112126	0.000				
11	100812_110736	100812_112126	0.000				
12	100812_110736	100812_112126	0.000				
13	100812_110736	100812_112126	0.000				
14	100812_110736	100812_112126	0.000				
15	100812_110736	100812_112126	0.000				

RiPROCESS Report – Lines 5+8

Worst 15 observations				
#	Object 1	Object 2	Deviation	Description
1	100812_110736	100812_112126	0.093	
2	100812_110736	100812_112126	0.091	
3	100812_110736	100812_112126	-0.091	
4	100812_110736	100812_112126	0.086	
5	100812_110736	100812_112126	0.084	
6	100812_110736	100812_112126	0.081	
7	100812_110736	100812_112126	-0.081	
8	100812_110736	100812_112126	-0.077	
9	100812_110736	100812_112126	0.076	
10	100812_110736	100812_112126	-0.075	
11	100812_110736	100812_112126	-0.075	
12	100812_110736	100812_112126	-0.073	
13	100812_110736	100812_112126	0.071	
14	100812_110736	100812_112126	-0.070	
15	100812_110736	100812_112126	0.067	
Best 2 scans				
Name		Objects	Std. dev.	
100812_112126		686	0.021	
100812_110736		686	0.021	
Worst 2 scans				
Name		Objects	Std. dev.	
100812_110736		686	0.021	
100812_112126		686	0.021	

Histogram of residues**Orientation chart**

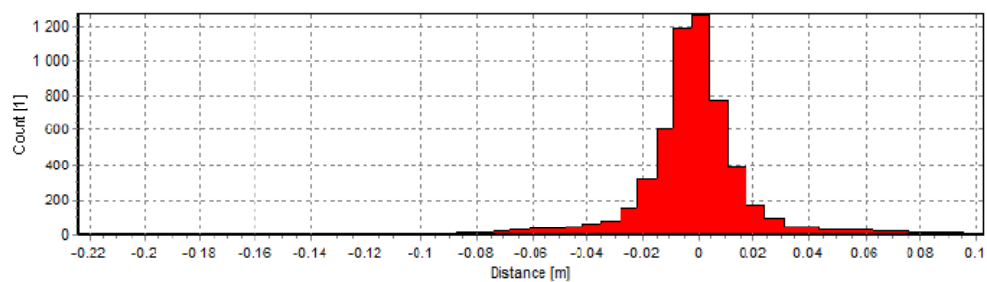
RiPROCESS Report – Lines 2+3+6+7

RiPROCESS Scan Data Adjustment Protocol							
Project:				Grasbrook-RiProcess			
Protocol date:				2010-12-30 19:38			
Operator:				Thomas Thies			
Comments:							
Program version:				RiPROCESS v1.4.5 (2010-09-22)			
Computer:				THOMASTHIES-PC			
Physical units:				m, deg			
Observation parameters							
Calculation parameters							
Calculation mode:				Adjustment			
Calculation time:				1 sec, 364 msecs			
Calculation mode:				Least Square Fit			
Tolerance:				0.010000			
Search corresp. planes:				False			
Search radius [m]:				1.000			
Angular tolerance [deg]:				5.000			
Max. normal dist. [m]:				1.000			
Observations active:				True			
Observations count:				5594			
Calculation results							
Number of free parameters:				0			
Number of observations:				5594			
Error (Std. deviation) [m]:				0.0220			
Laser devices							
Name	Roll	Pitch	Yaw	X	Y	Z	Range Shift
Scanner 1 (VZ-400,)	0.02190	3.58260	0.16000	0.000	0.000	0.000	0.0000
- Confidence	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
Observations							
Best 15 observations							
#	Object 1	Object 2	Deviation	Description			
1	100812_105504	100812_111623	0.000				
2	100812_105504	100812_111226	0.000				
3	100812_111226	100812_111623	0.000				
4	100812_111226	100812_111623	0.000				
5	100812_111226	100812_111623	0.000				
6	100812_105920	100812_111226	0.000				
7	100812_105504	100812_111226	0.000				
8	100812_111226	100812_111623	0.000				
9	100812_105920	100812_111226	0.000				
10	100812_111226	100812_111623	0.000				
11	100812_105504	100812_111226	0.000				
12	100812_105920	100812_111623	0.000				
13	100812_105920	100812_111226	0.000				
14	100812_105920	100812_111226	0.000				
15	100812_111226	100812_111623	0.000				

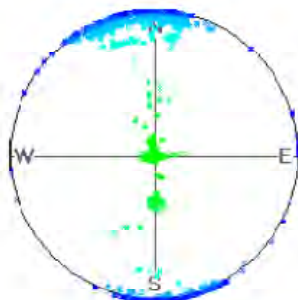
RiPROCESS Report – Lines 2+3+6+7

Worst 15 observations				
#	Object 1	Object 2	Deviation	Description
1	100812_105920	100812_111623	-0.221	
2	100812_105920	100812_111623	0.099	
3	100812_105504	100812_111226	-0.099	
4	100812_105504	100812_111226	-0.099	
5	100812_111226	100812_111623	0.098	
6	100812_105504	100812_111623	-0.098	
7	100812_105504	100812_111623	0.098	
8	100812_105504	100812_111623	0.097	
9	100812_105920	100812_111226	0.097	
10	100812_111226	100812_111623	-0.097	
11	100812_105504	100812_105920	-0.097	
12	100812_111226	100812_111623	-0.096	
13	100812_111226	100812_111623	-0.096	
14	100812_105920	100812_111226	-0.095	
15	100812_105504	100812_105920	-0.095	
Best 4 scans				
Name		Objects	Std. dev.	
100812_111226		3021	0.021	
100812_105504		2580	0.022	
100812_111623		2909	0.022	
100812_105920		2678	0.023	
Worst 4 scans				
Name		Objects	Std. dev.	
100812_105920		2678	0.023	
100812_111623		2909	0.022	
100812_105504		2580	0.022	
100812_111226		3021	0.021	

Histogram of residues



Orientation chart

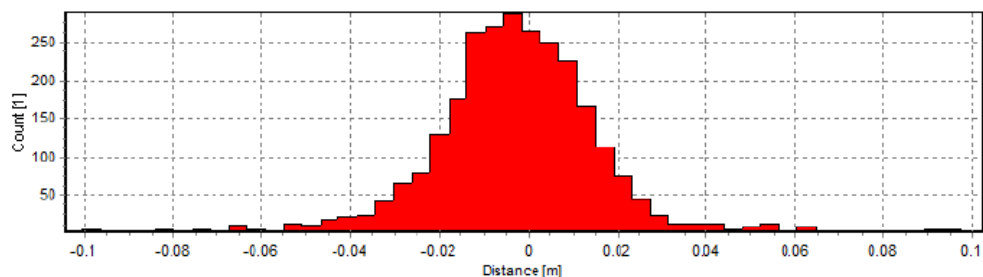
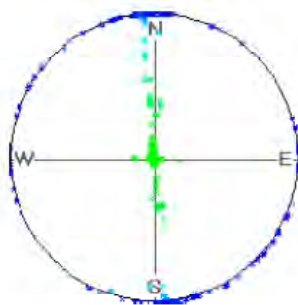


RiPROCESS Report – Lines 1+4+5+8

RiPROCESS Scan Data Adjustment Protocol							
Project:				Grasbrook-RiProcess			
Protocol date:				2010-12-30 19:40			
Operator:				Thomas Thies			
Comments:							
Program version:				RiPROCESS v1.4.5 (2010-09-22)			
Computer:				THOMASTHIES-PC			
Physical units:				m, deg			
Observation parameters							
Calculation parameters							
Calculation mode:				Adjustment			
Calculation time:				5/9 msecs			
Calculation mode:				Least Square Fit			
Tolerance:				0.010000			
Search corresp. planes:				False			
Search radius [m]:				1.000			
Angular tolerance [deg]:				5.000			
Max. normal dist. [m]:				1.000			
Observations active:				True			
Observations count:				2742			
Calculation results							
Number of free parameters:				0			
Number of observations:				2/42			
Error (Std. deviation) [m]:				0.0228			
Laser devices							
Name	Roll	Pitch	Yaw	X	Y	Z	Range Shift
Scanner 1 (VZ-400,)	0.02190	3.58260	0.16000	0.000	0.000	0.000	0.0000
- Confidence	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
Observations							
Best 15 observations							
#	Object 1	Object 2	Deviation	Description			
1	100812_105024	100812_110414	0.000				
2	100812_105074	100812_110414	0.000				
3	100812_110414	100812_112126	0.000				
4	100812_110736	100812_112126	0.000				
5	100812_110414	100812_110736	0.000				
6	100812_105024	100812_110736	0.000				
7	100812_110414	100812_112126	0.000				
8	100812_105024	100812_110736	0.000				
9	100812_105024	100812_110736	0.000				
10	100812_105024	100812_110414	0.000				
11	100812_105024	100812_110736	0.000				
12	100812_110414	100812_110736	0.000				
13	100812_110414	100812_112126	0.000				
14	100812_110736	100812_112126	0.000				
15	100812_110736	100812_112126	0.000				

RiPROCESS Report – Lines 1+4+5+8

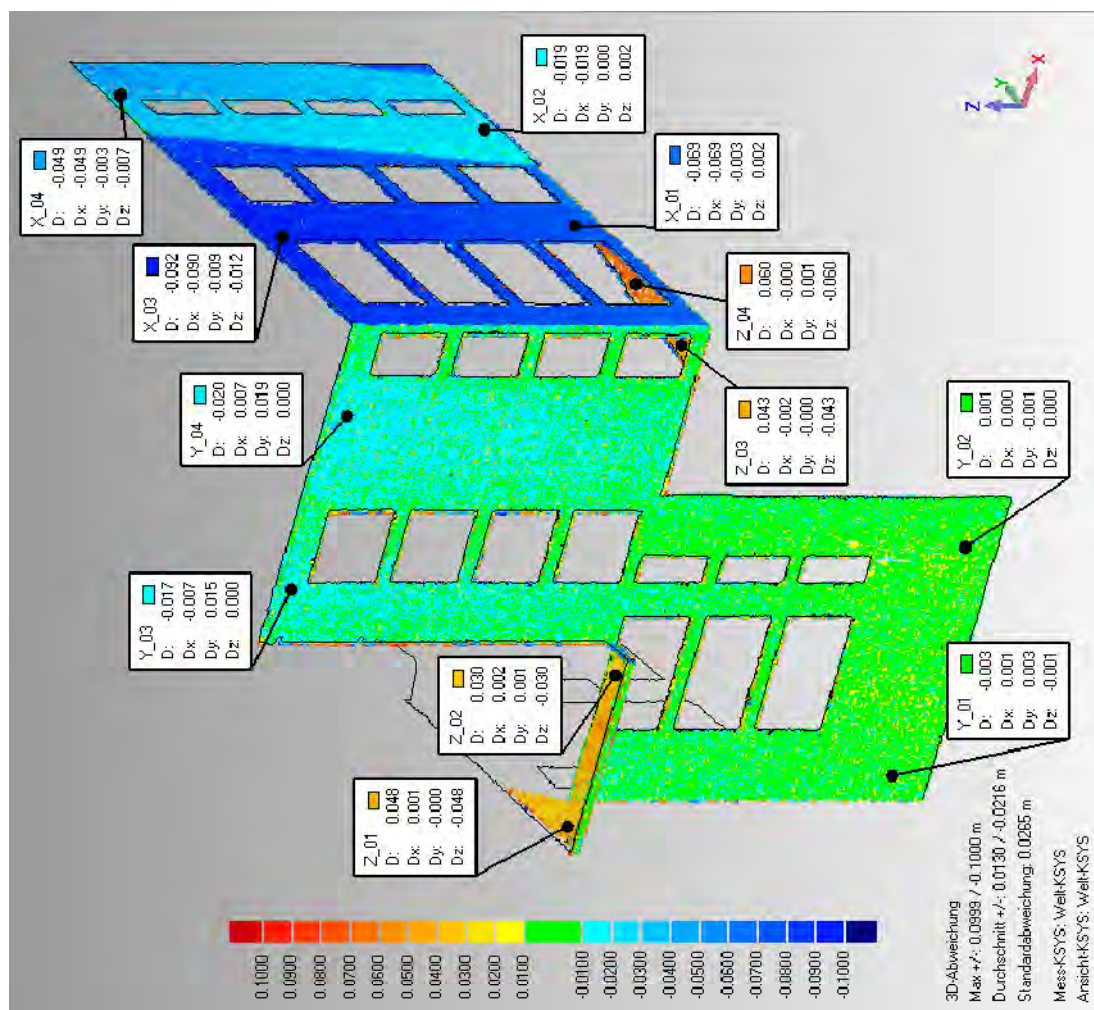
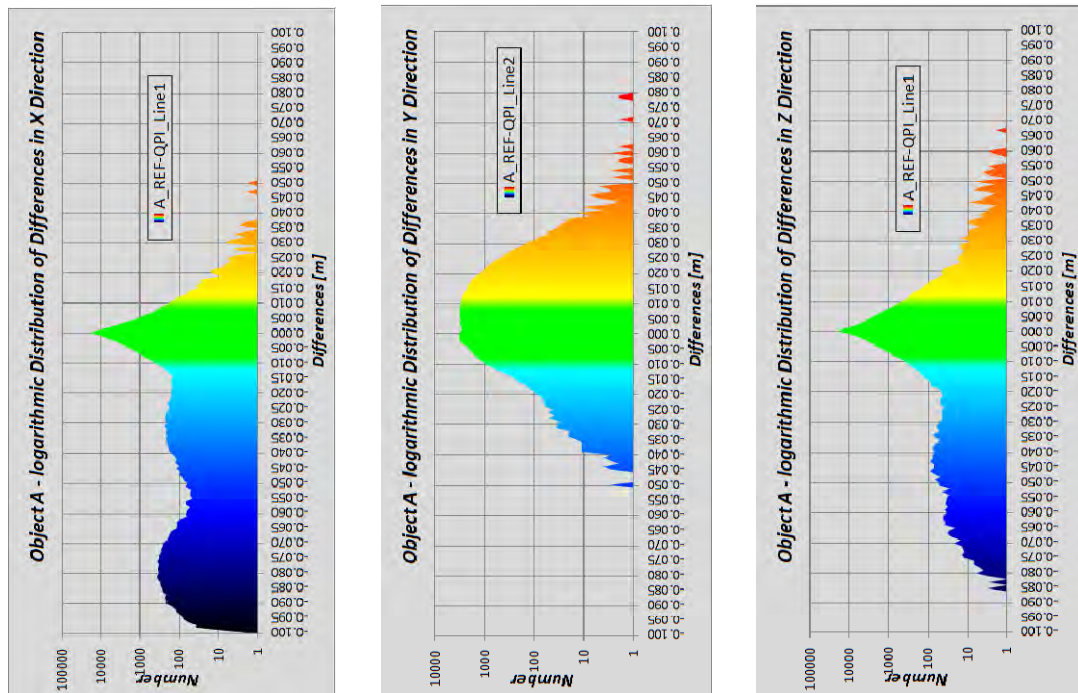
Worst 15 observations				
#	Object 1	Object 2	Deviation	Description
1	100812_110736	100812_112126	-0.102	
2	100812_110414	100812_110736	0.100	
3	100812_105024	100812_112126	-0.100	
4	100812_105024	100812_110736	-0.099	
5	100812_110414	100812_112126	-0.099	
6	100812_110414	100812_112126	-0.097	
7	100812_105024	100812_112126	0.097	
8	100812_105024	100812_110736	-0.097	
9	100812_110414	100812_110736	-0.096	
10	100812_110414	100812_112126	0.096	
11	100812_110414	100812_112126	-0.096	
12	100812_105024	100812_110414	0.095	
13	100812_105024	100812_112126	0.095	
14	100812_110414	100812_112126	0.094	
15	100812_105024	100812_110736	0.094	
Best 4 scans				
Name		Objects	Std. dev.	
100812_110736		1585	0.021	
100812_105024		1231	0.022	
100812_110414		1140	0.023	
100812_112126		1528	0.024	
Worst 4 scans				
Name		Objects	Std. dev.	
100812_112126		1528	0.024	
100812_110414		1140	0.023	
100812_105024		1231	0.022	
100812_110736		1585	0.021	

Histogram of residues**Orientation chart**

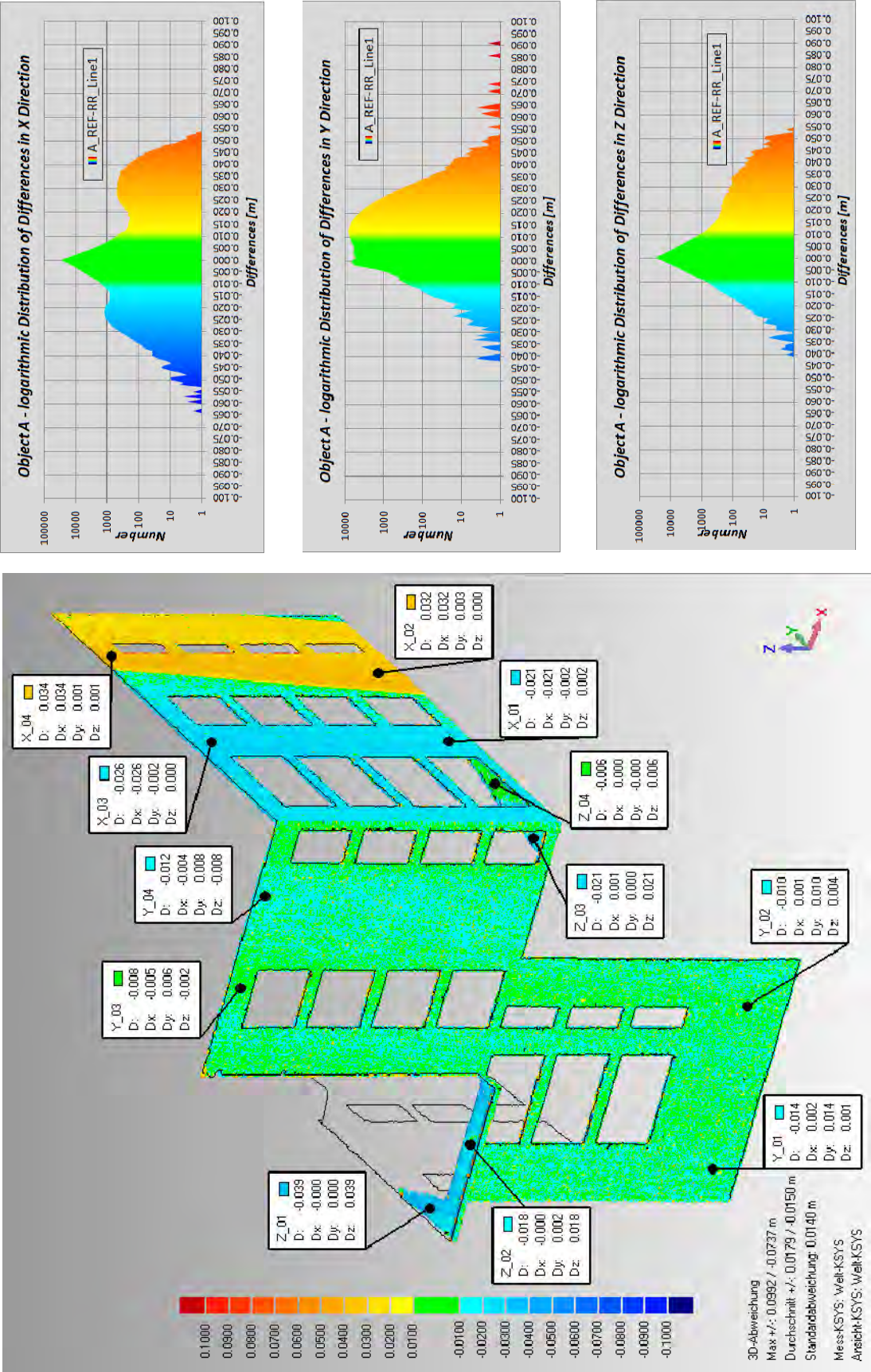
Appendix A-6

GEOMAGIC 3D Comparison Results – Absolute Accuracy Analysis

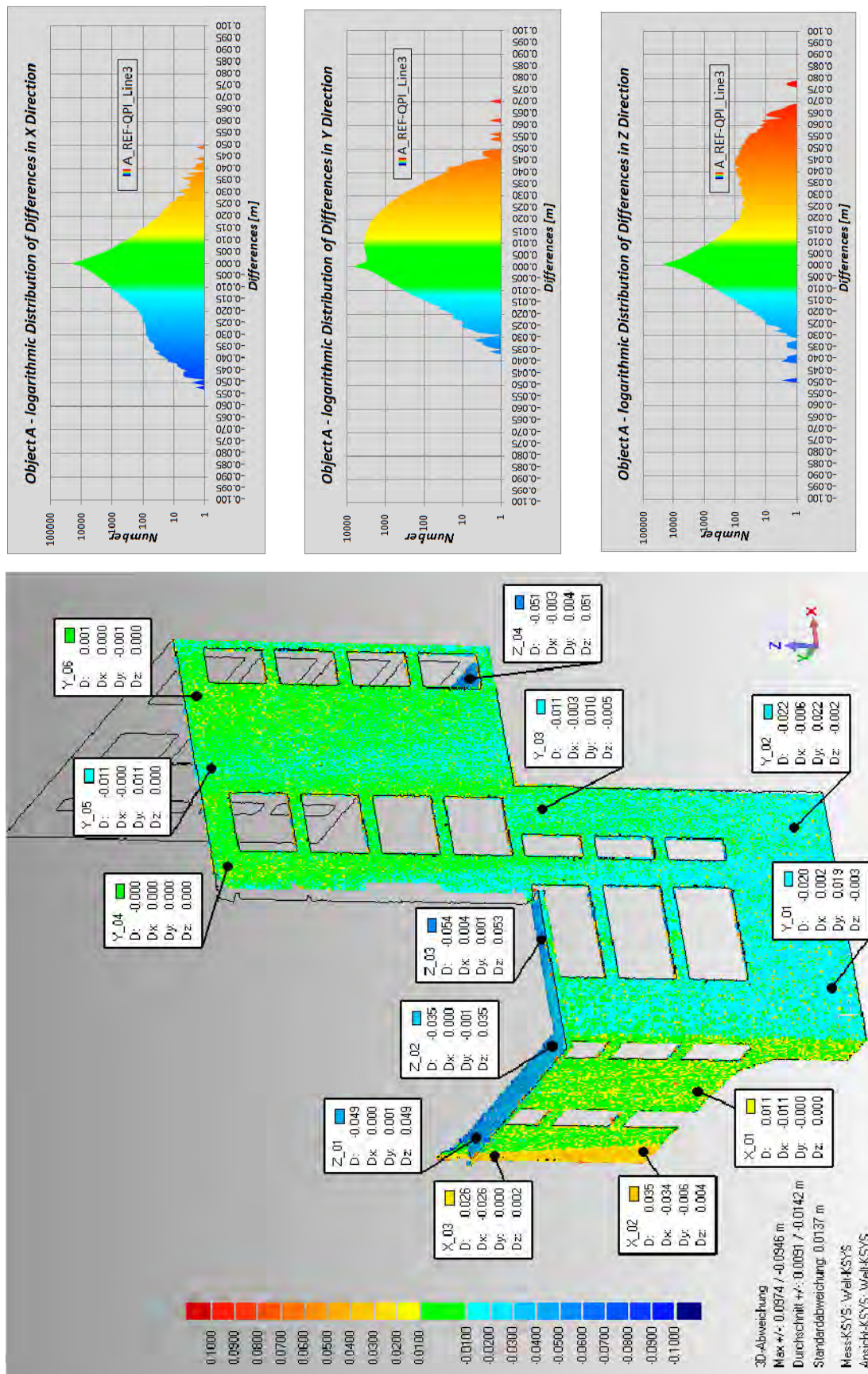
Object A Differences: Ref. / Line 1 - QINSy Postpro. INS



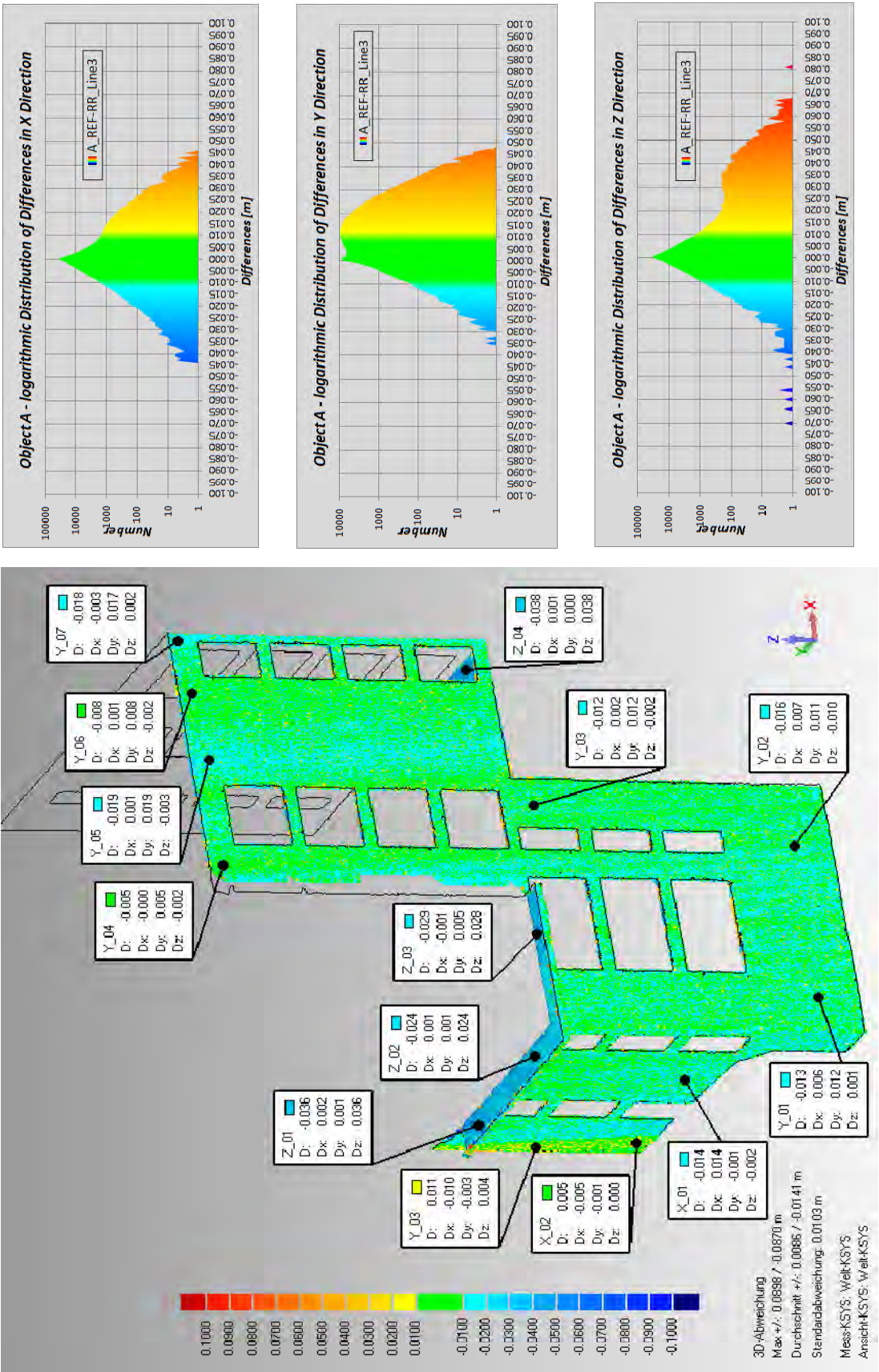
Object A Differences: Ref. / Line 1 – RiPROCESS Recalib.



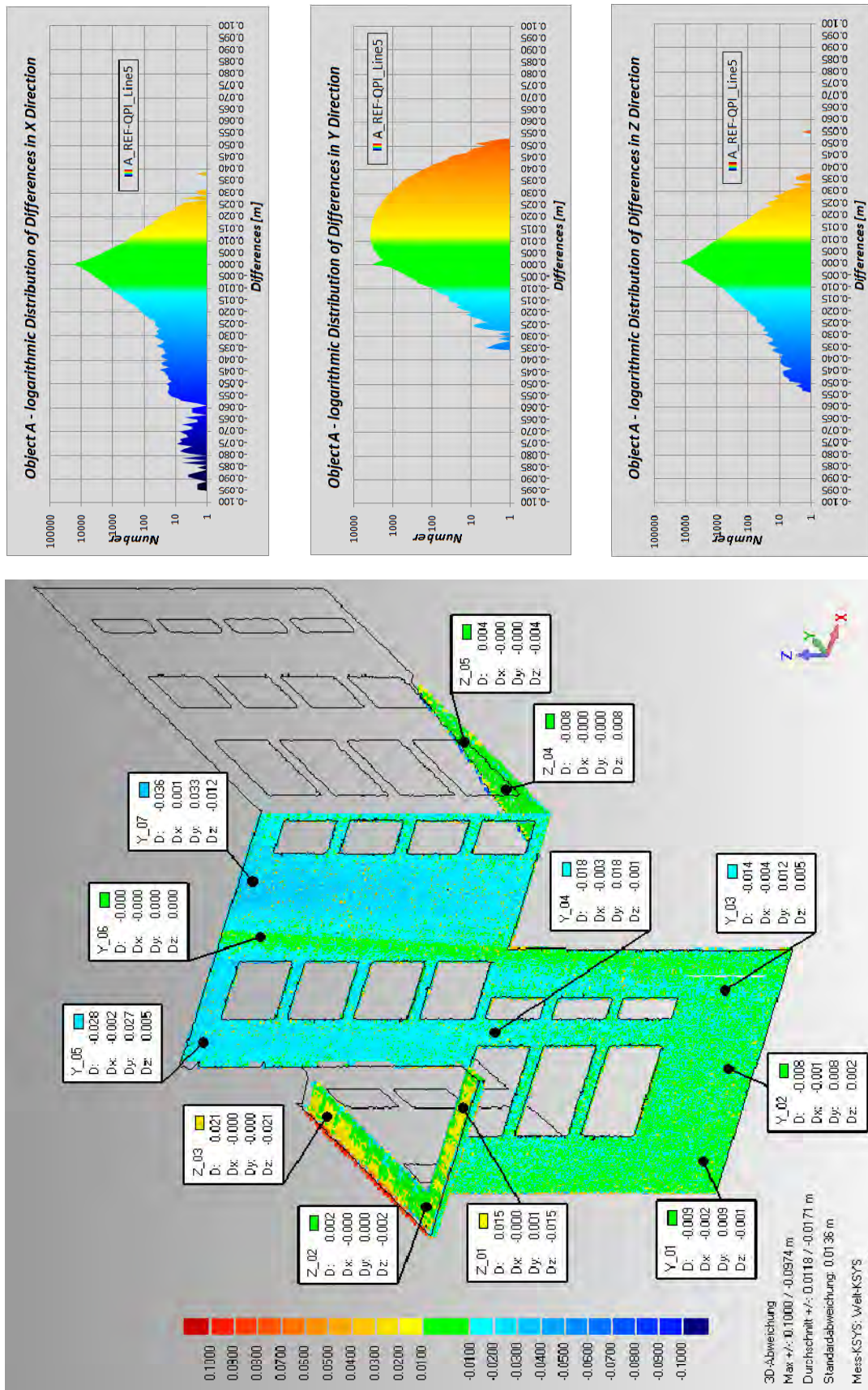
Object A Differences: Ref. / Line 3 - QINSy Postpro. INS



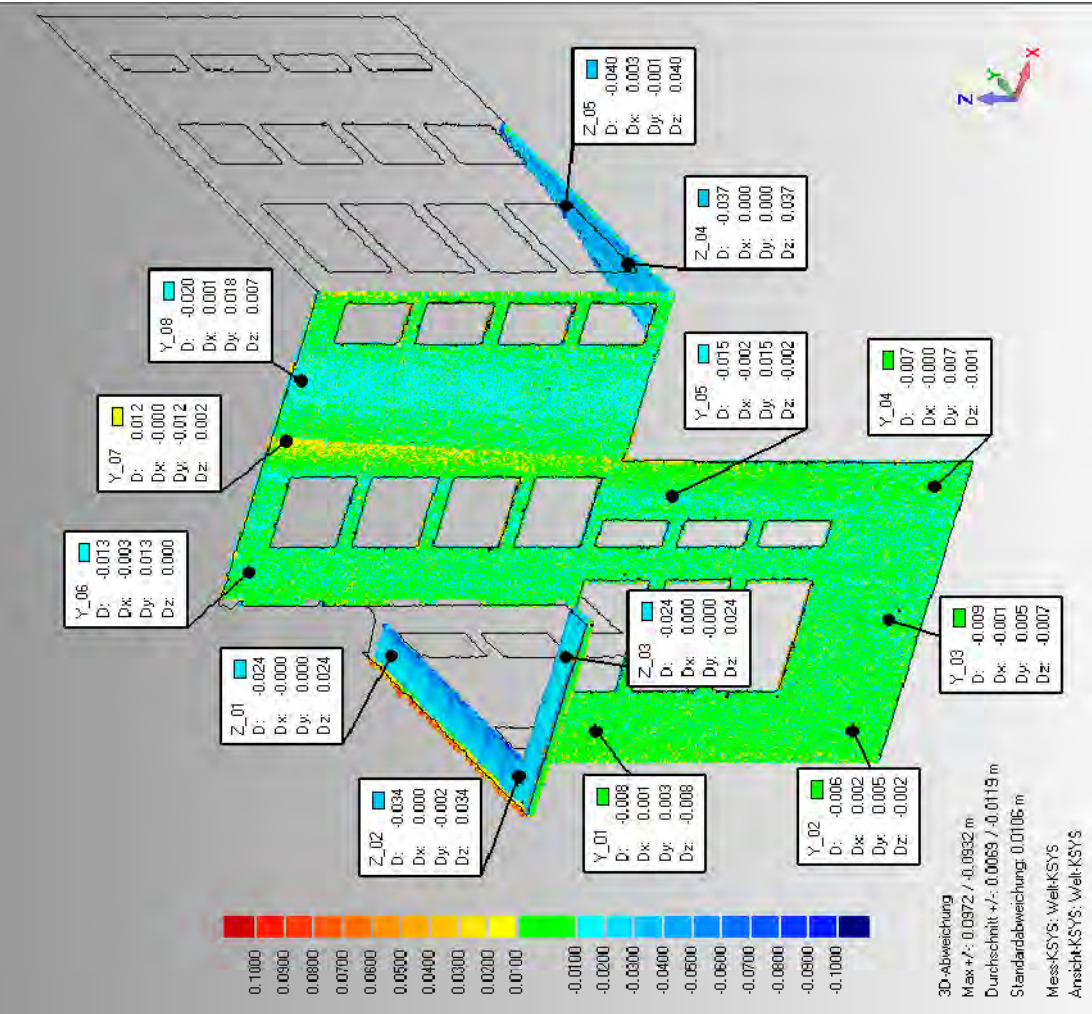
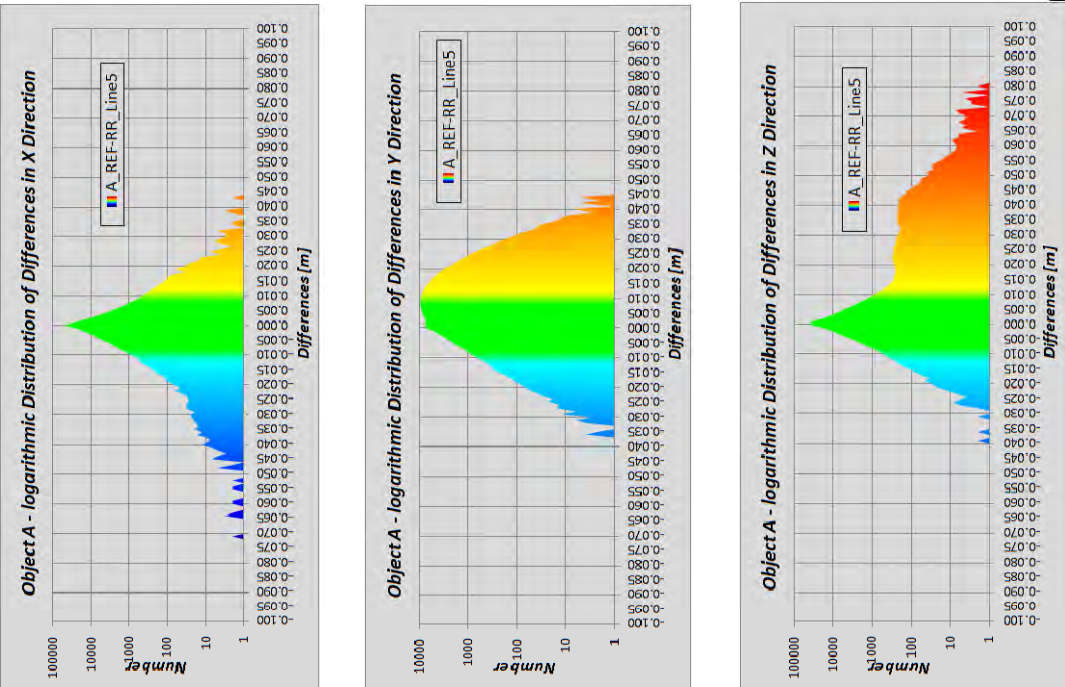
Object A Differences: Ref. / Line 3 - RiPROCESS Recalib.



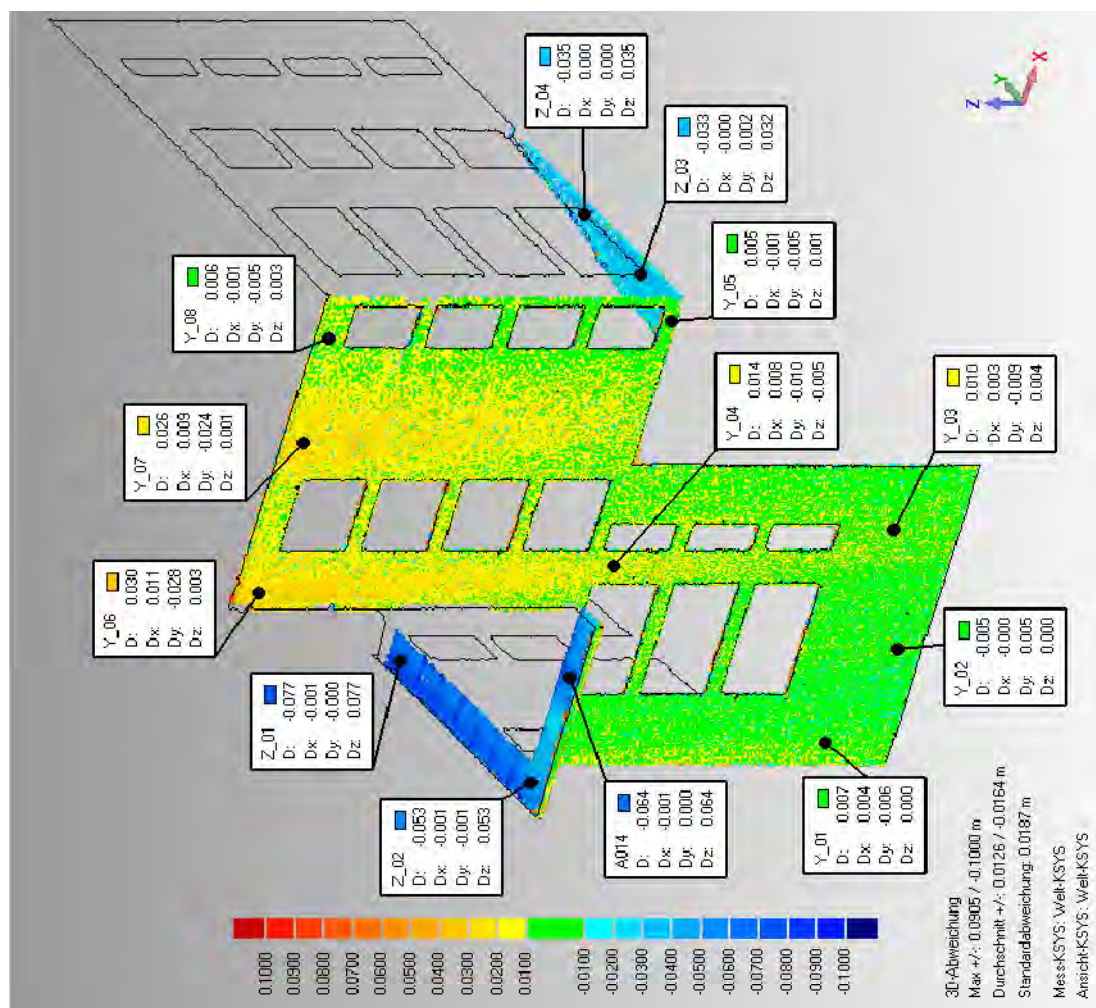
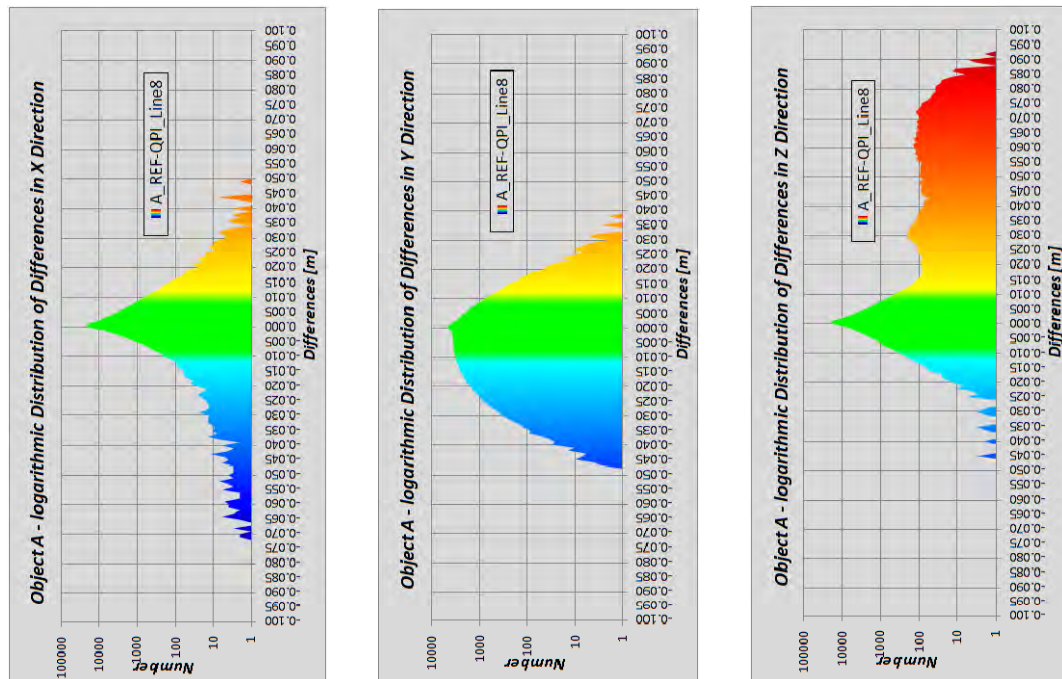
Object A Differences: Ref. / Line 5 - QINSy Postpro. INS



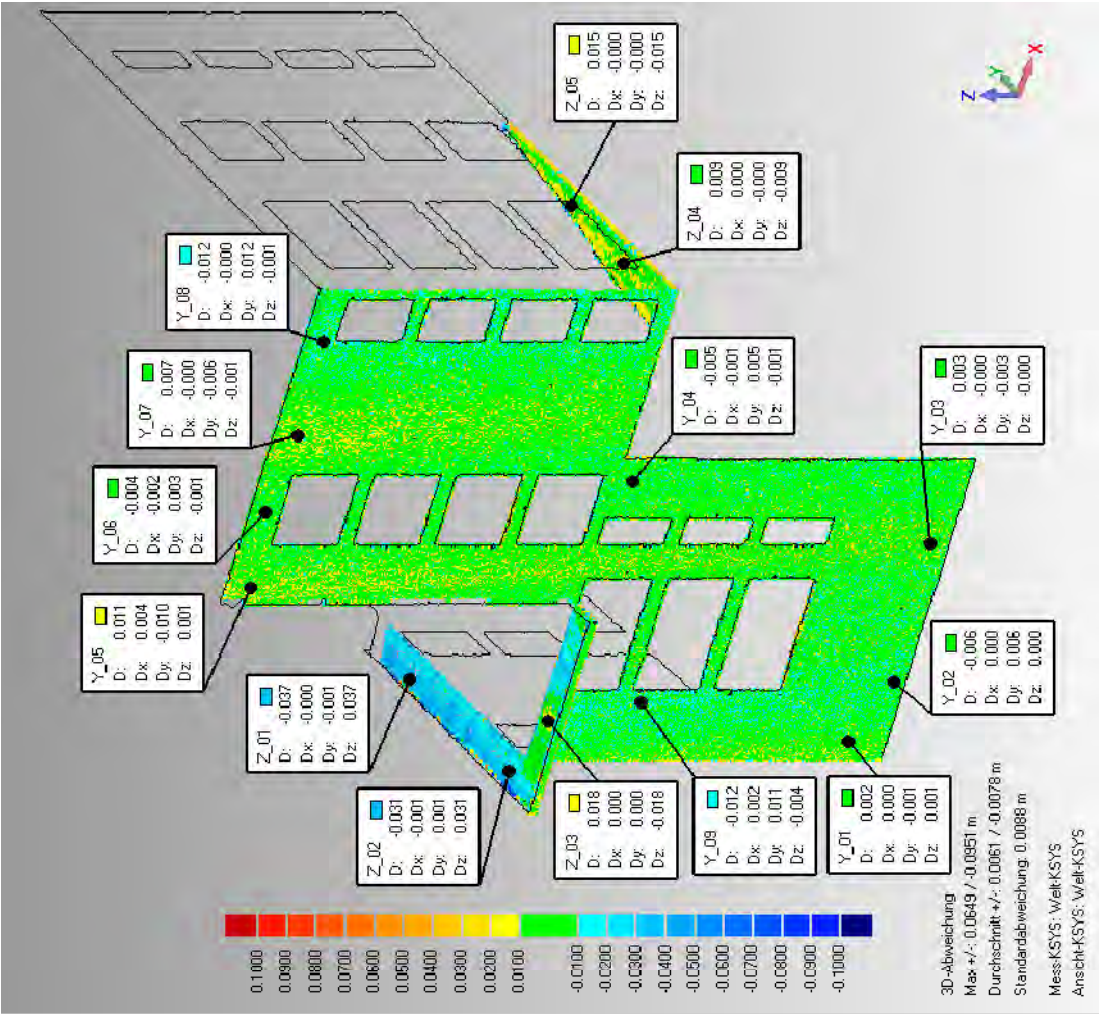
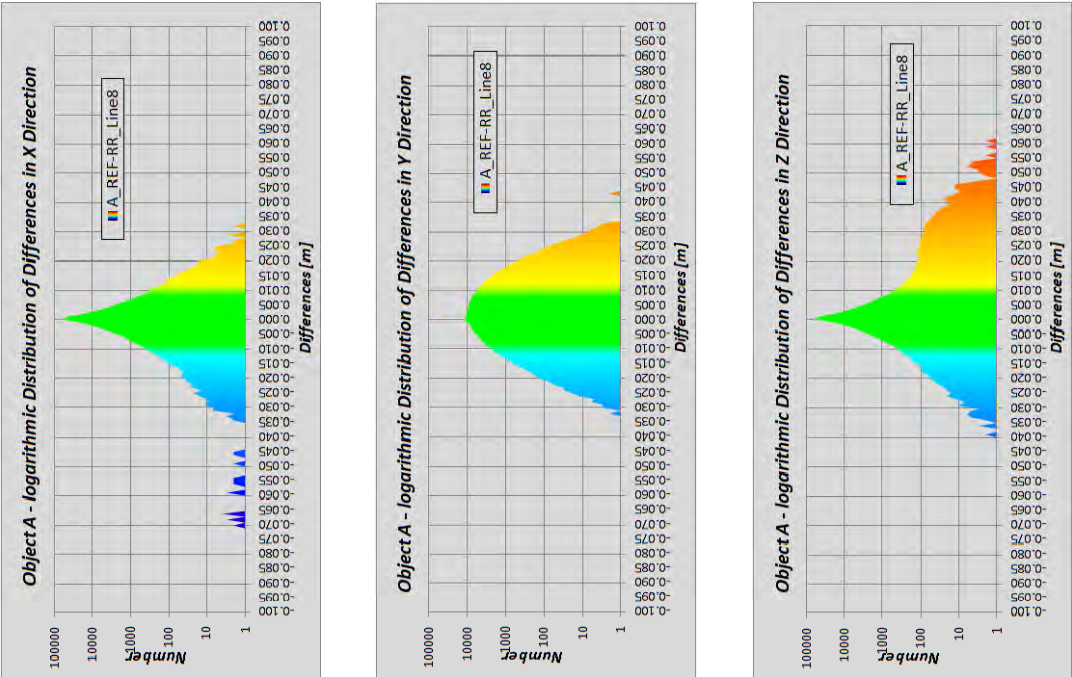
Object A Differences: Ref. / Line 5 - RiPROCESS Recalib.



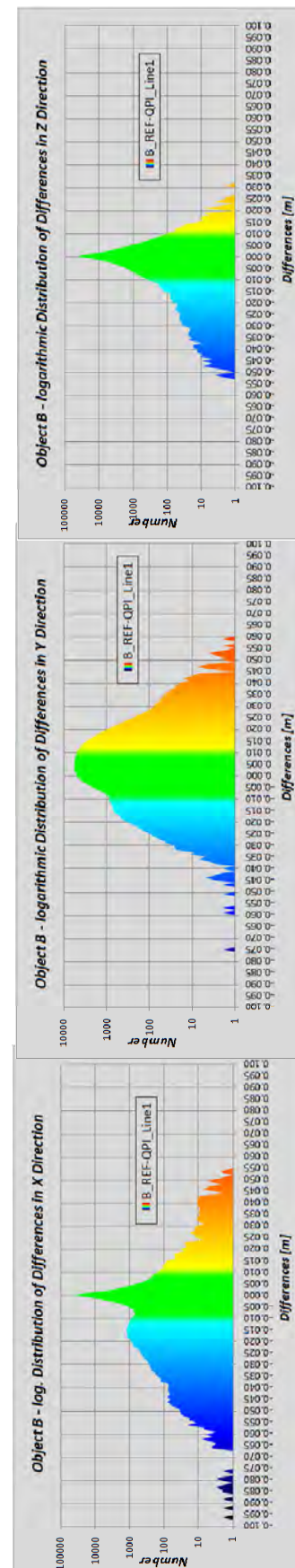
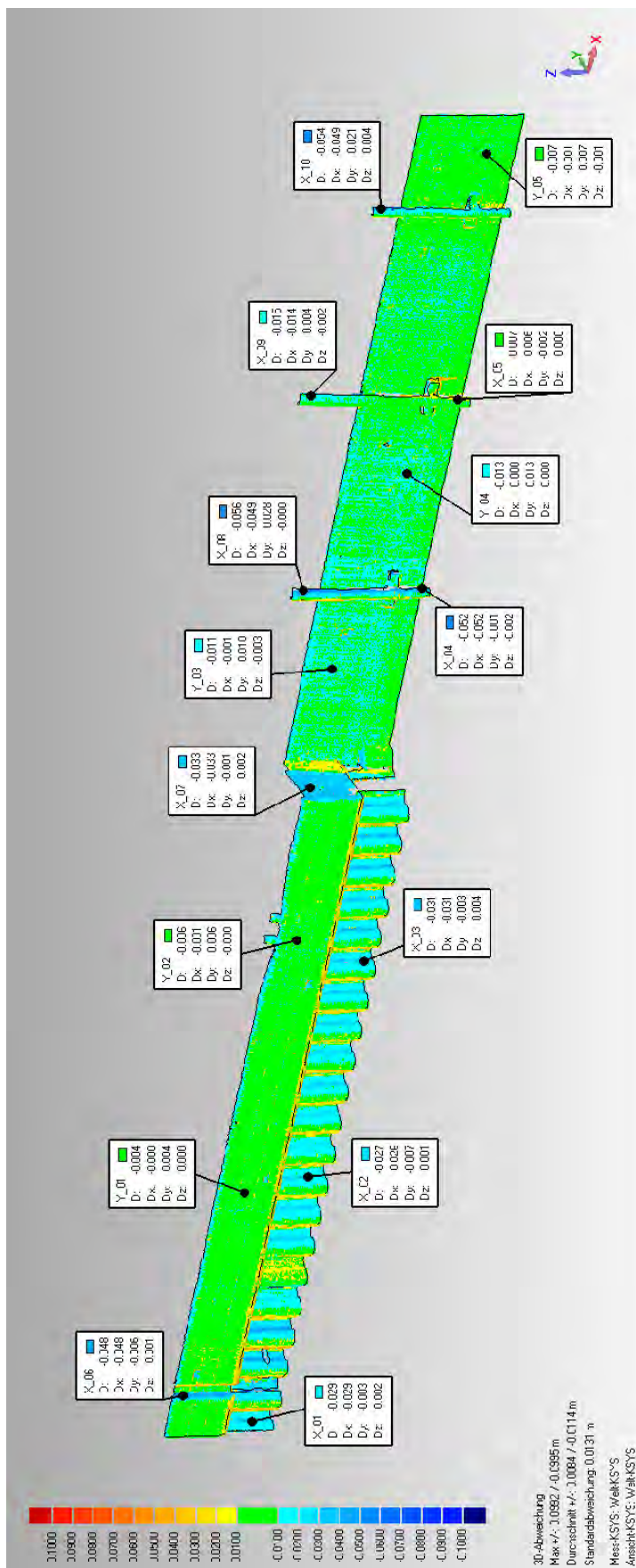
Object A Differences: Ref. / Line 8 - QINSy Postpro. INS



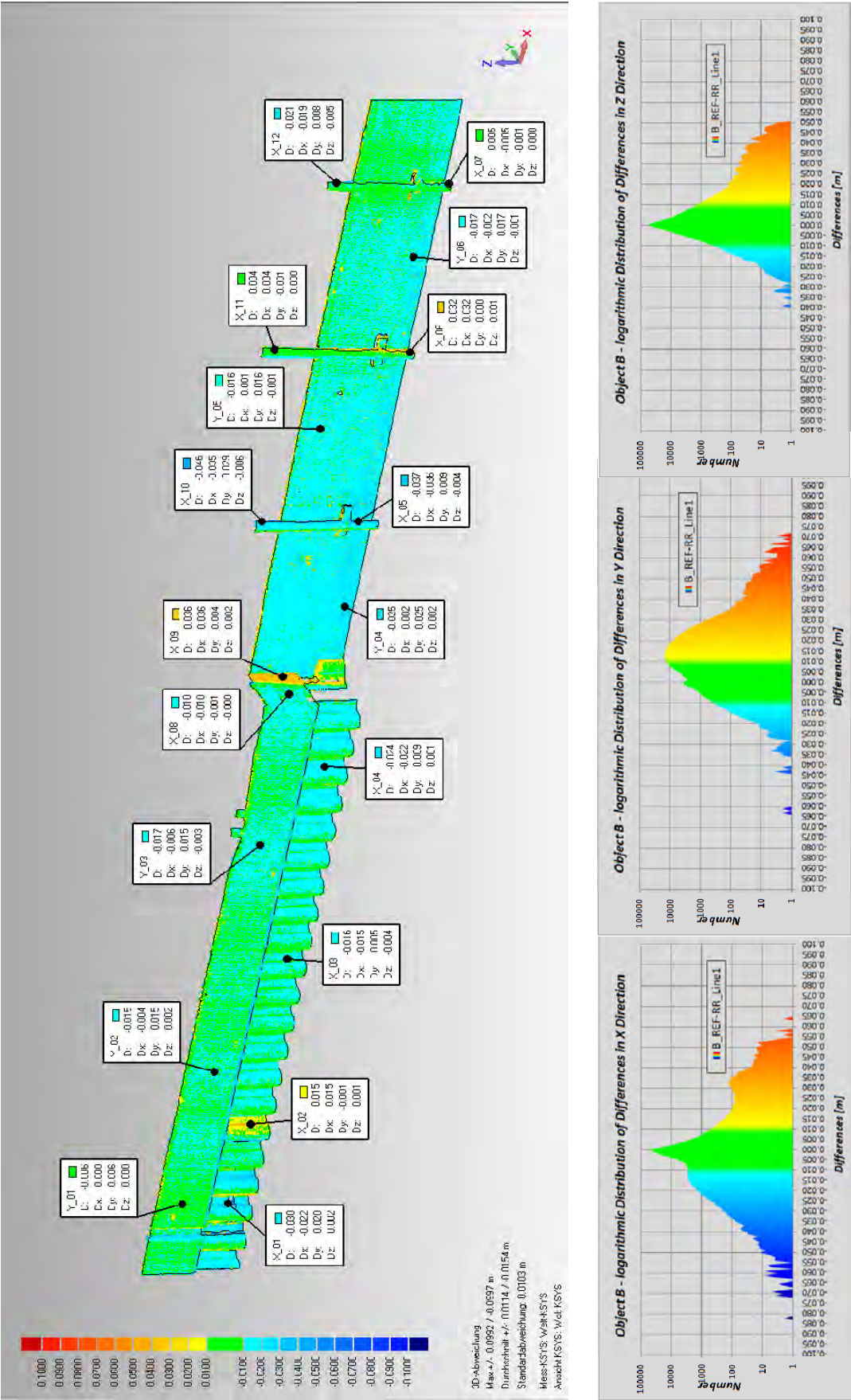
Object A Differences: Ref. / Line 8 - RiPROCESS Recalib.



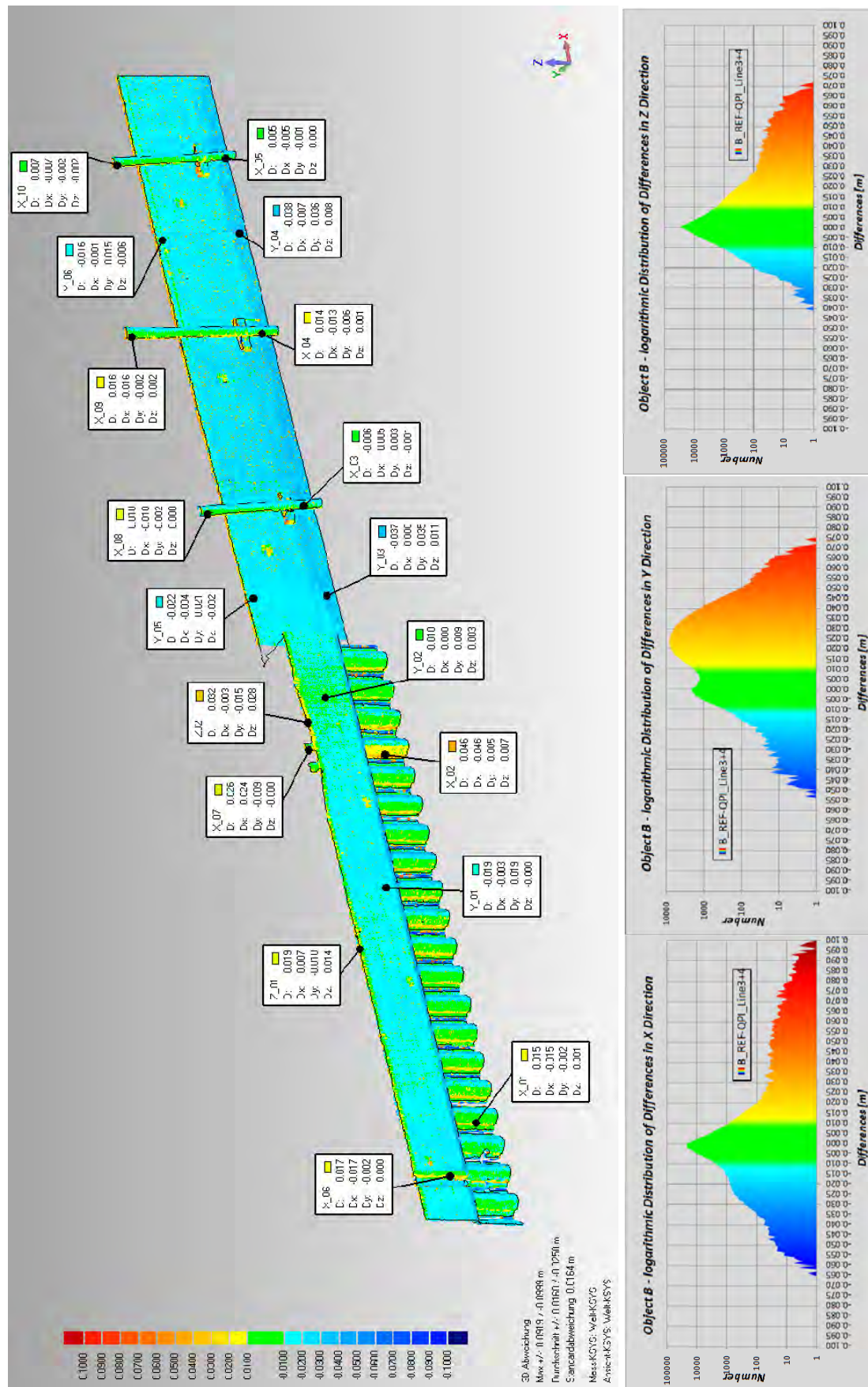
Object B Differences: Ref. / Line 1 - QINSy Postpro. INS



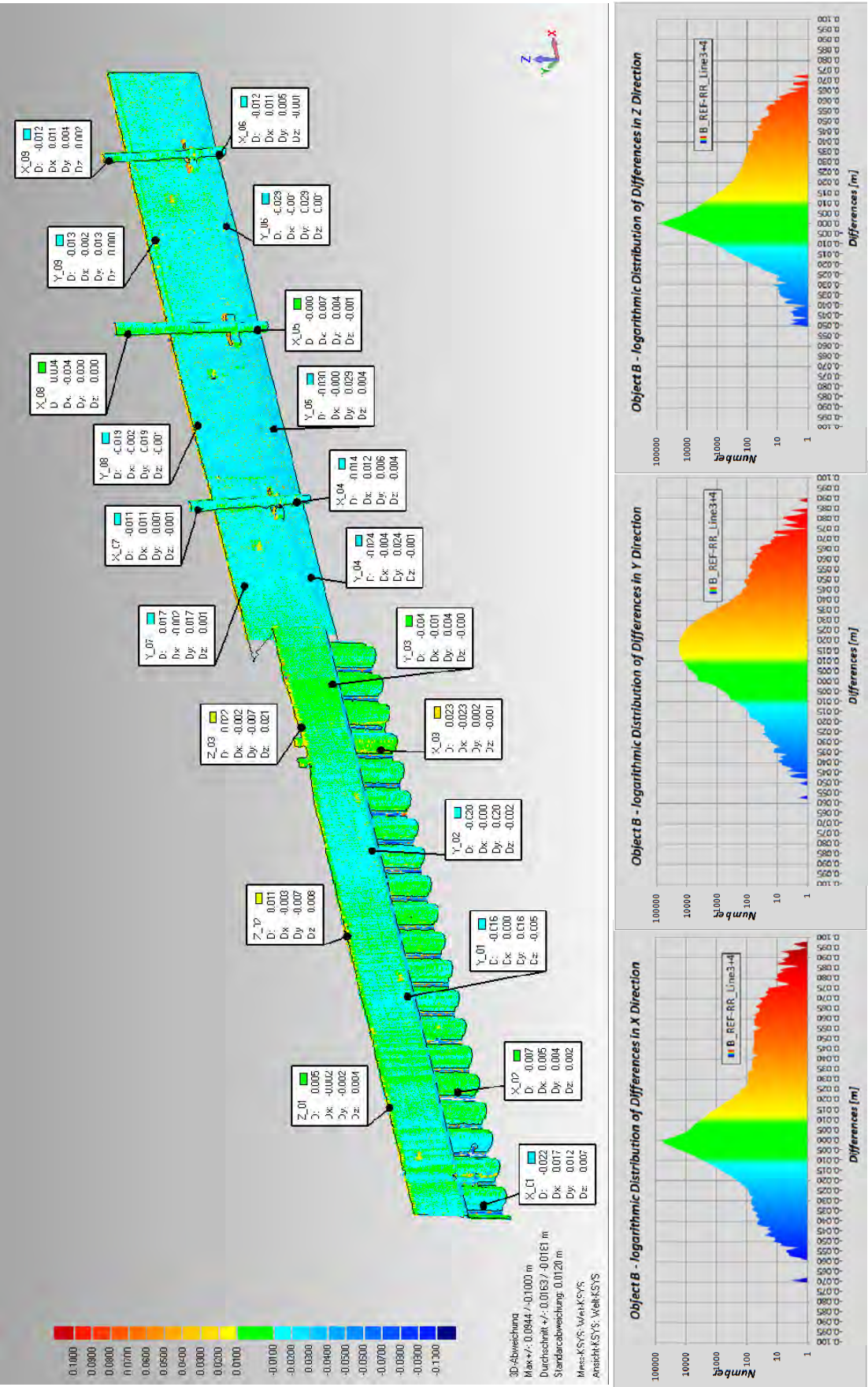
Object B Differences: Ref. / Line 1 – RiPROCESS Recalib.



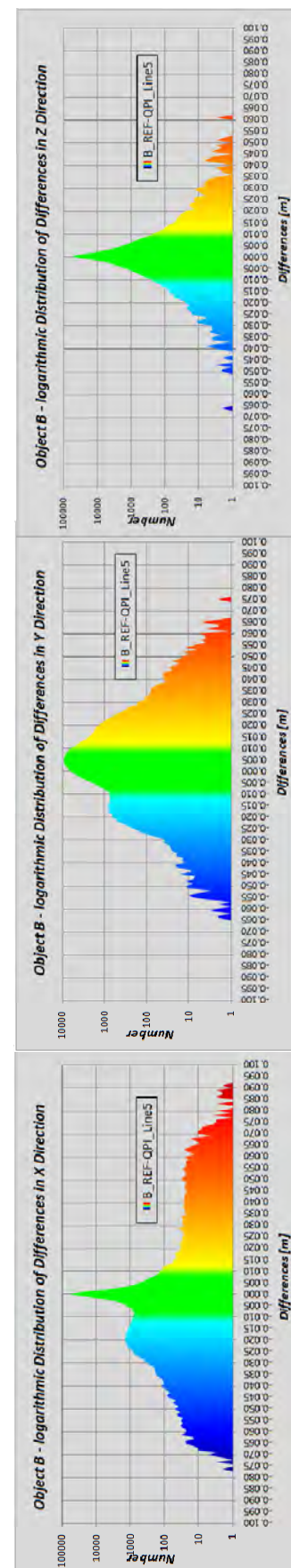
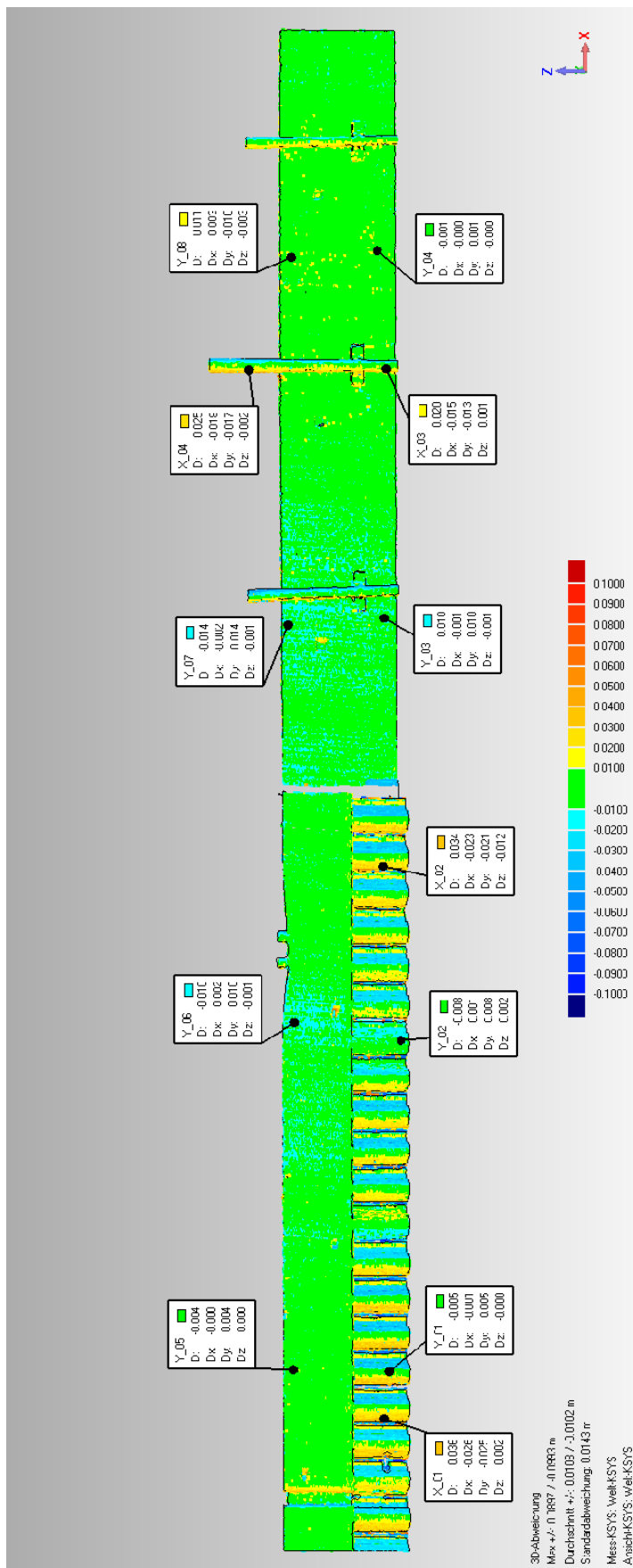
Object B Differences: Ref. / Line 3+4 - QINSy Postpro. INS



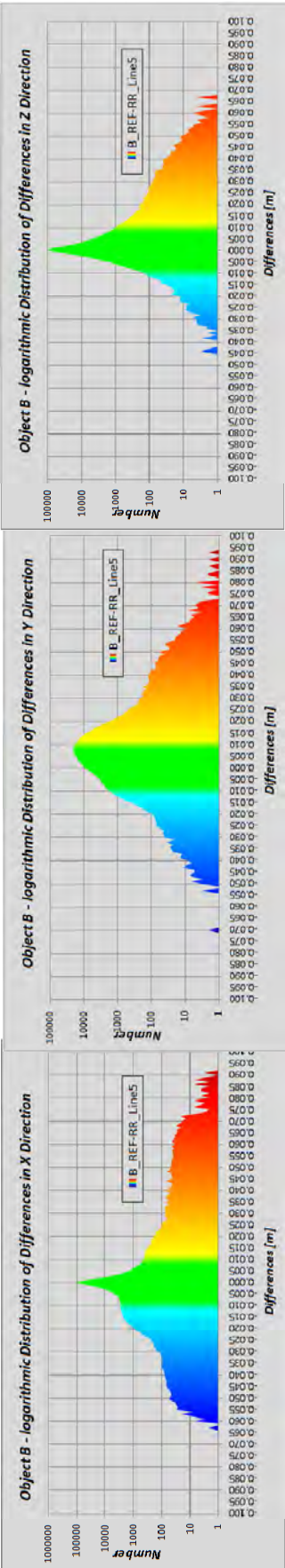
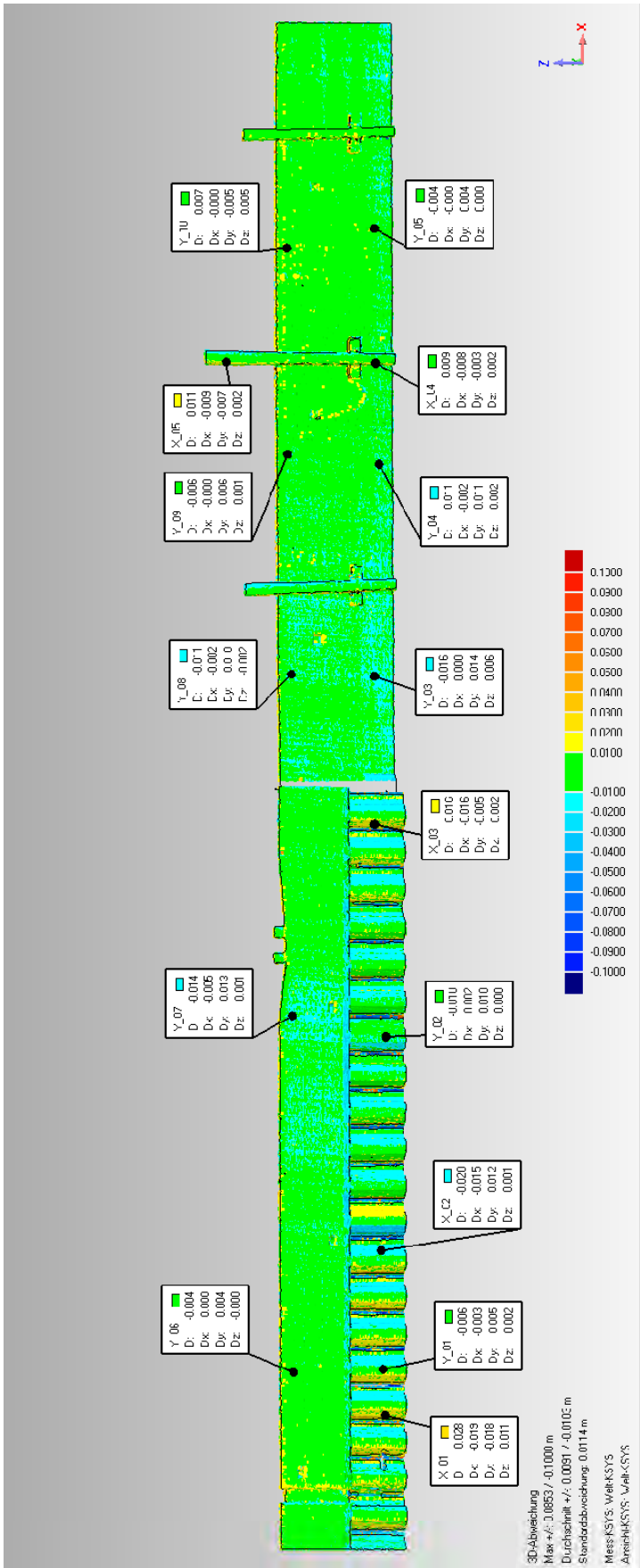
Object B Differences:Ref./Line3+4 – RiPROCESS Recalib.

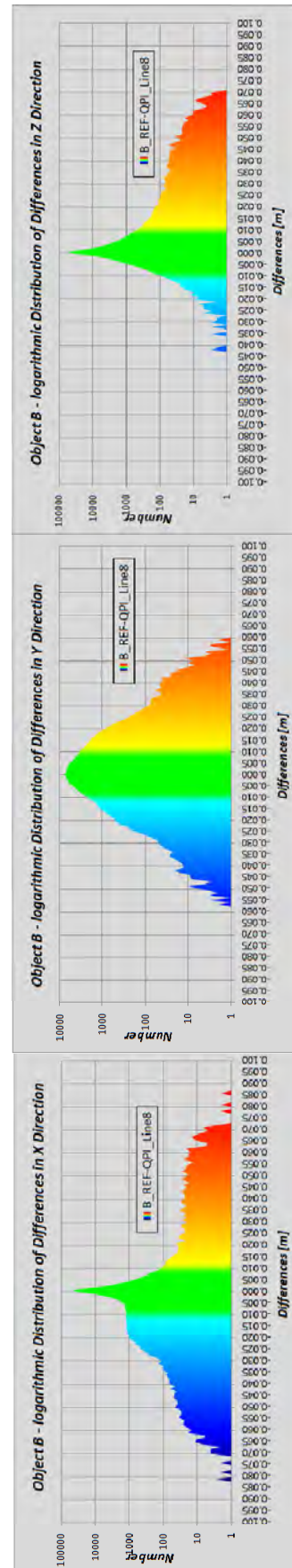


Object B Differences: Ref. / Line 5 - QINSy Postpro. INS

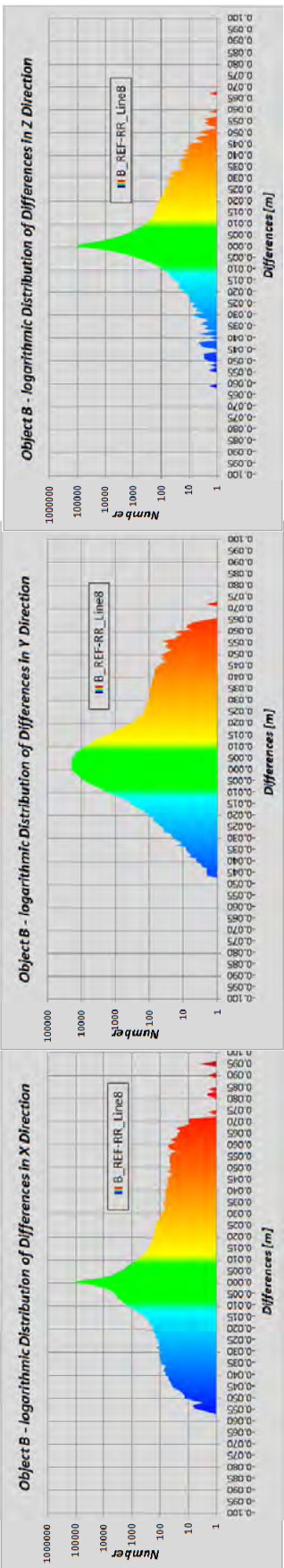
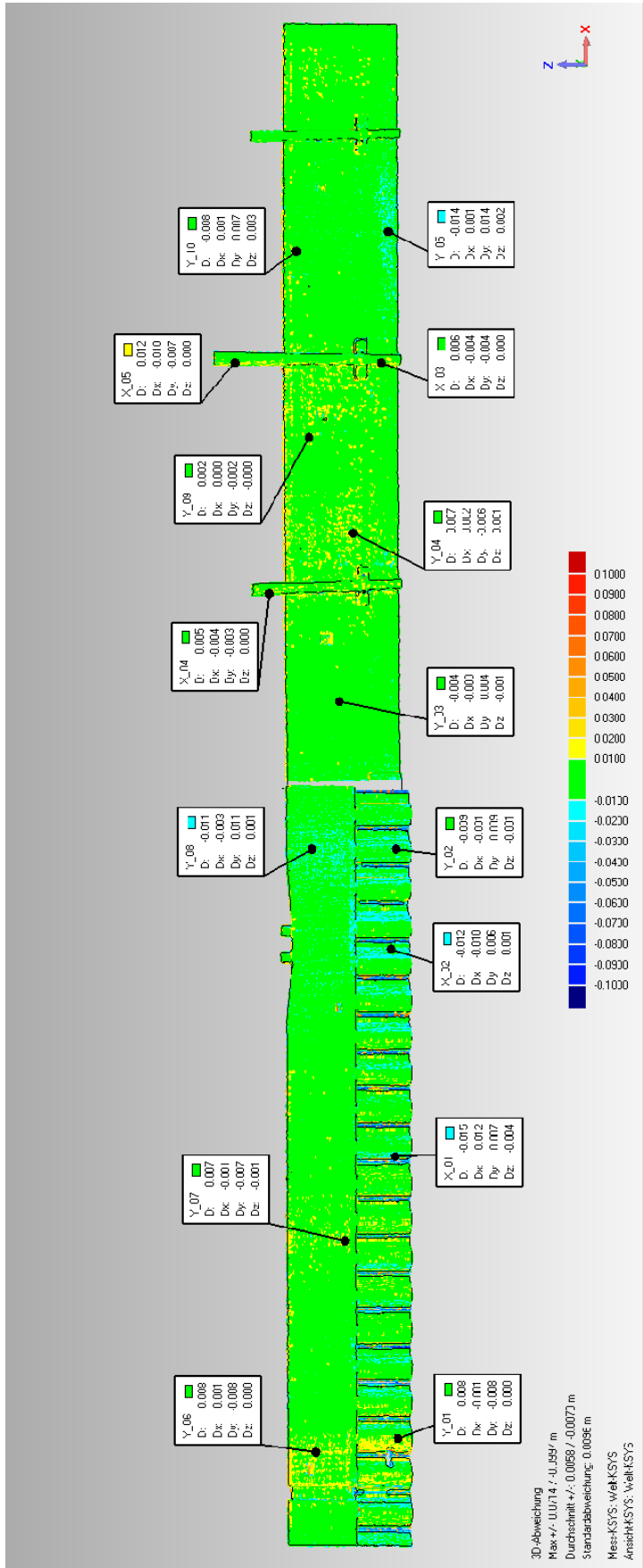


Object B Differences: Ref. / Line 5 – RiPROCESS Recalib.

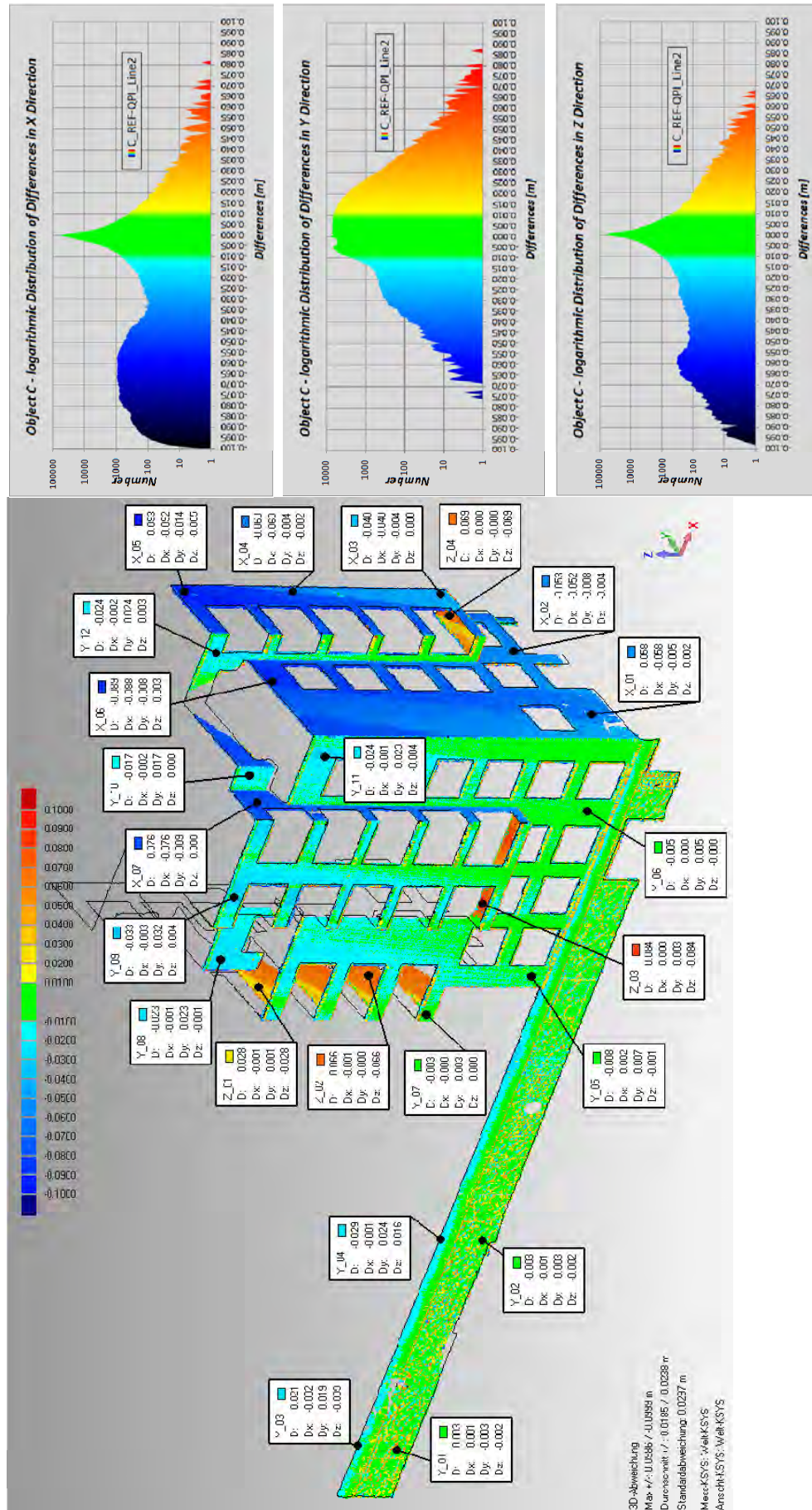




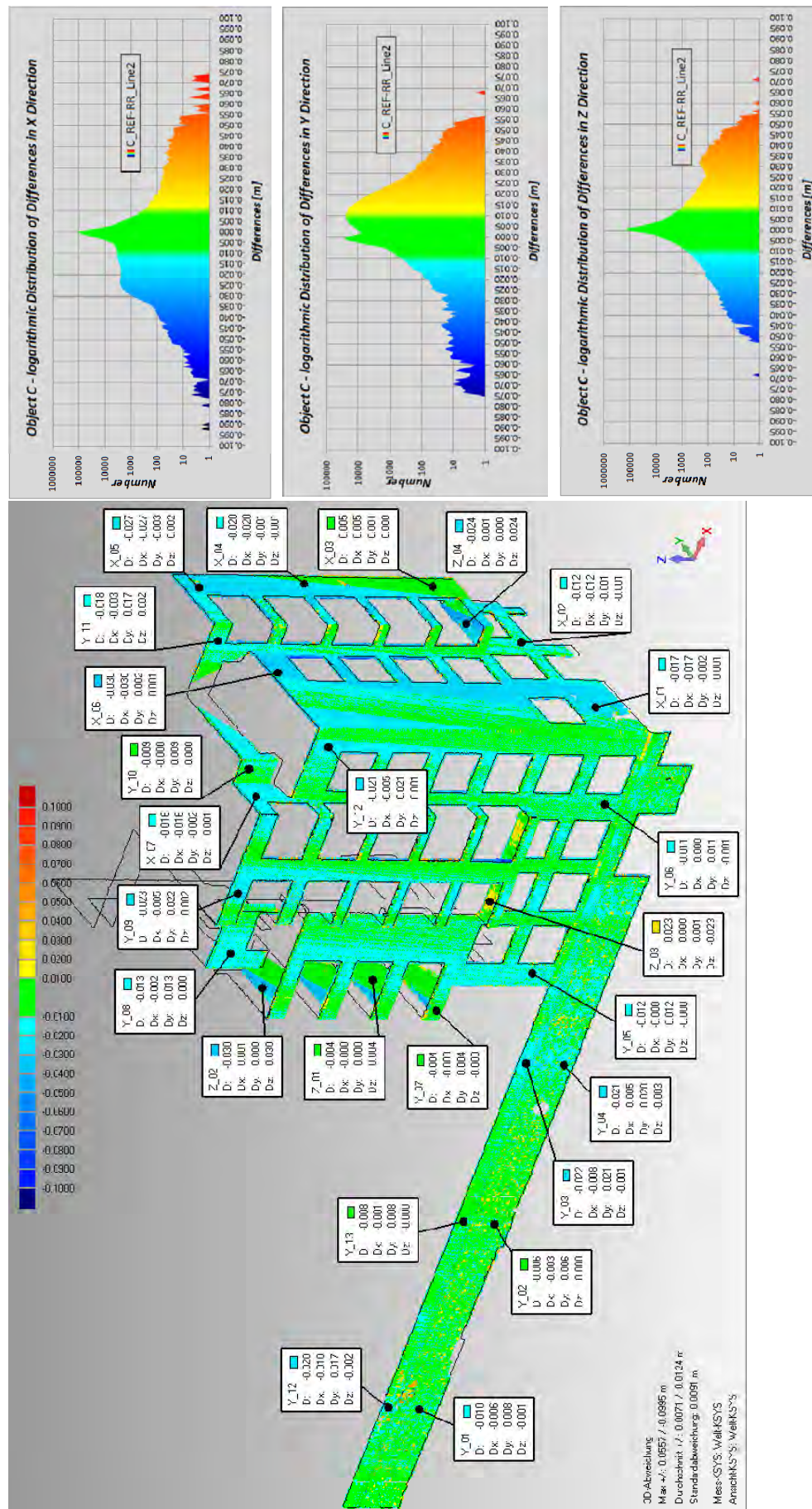
Object B Differences: Ref. / Line 8 – RiPROCESS Recalib.



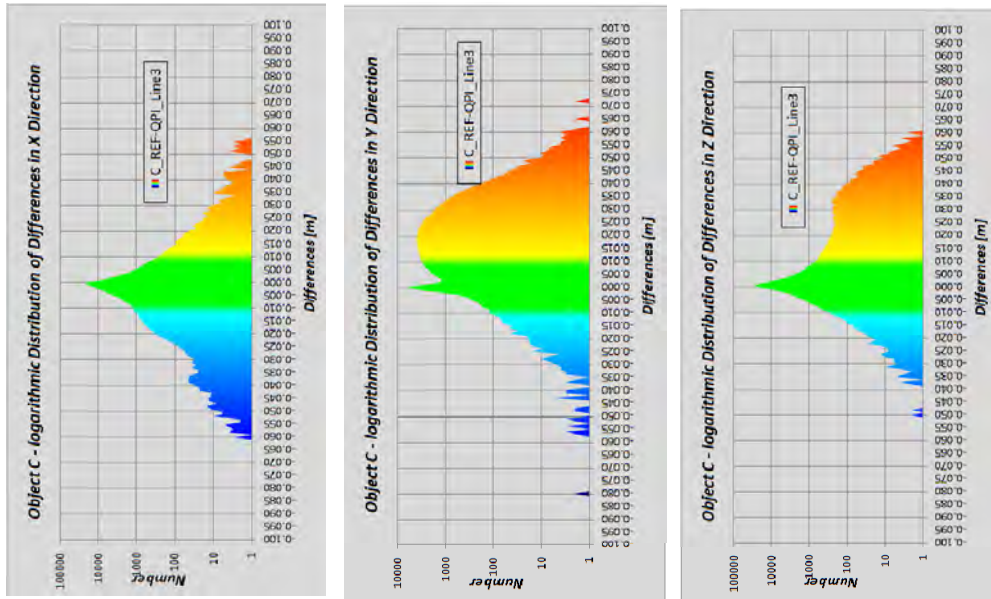
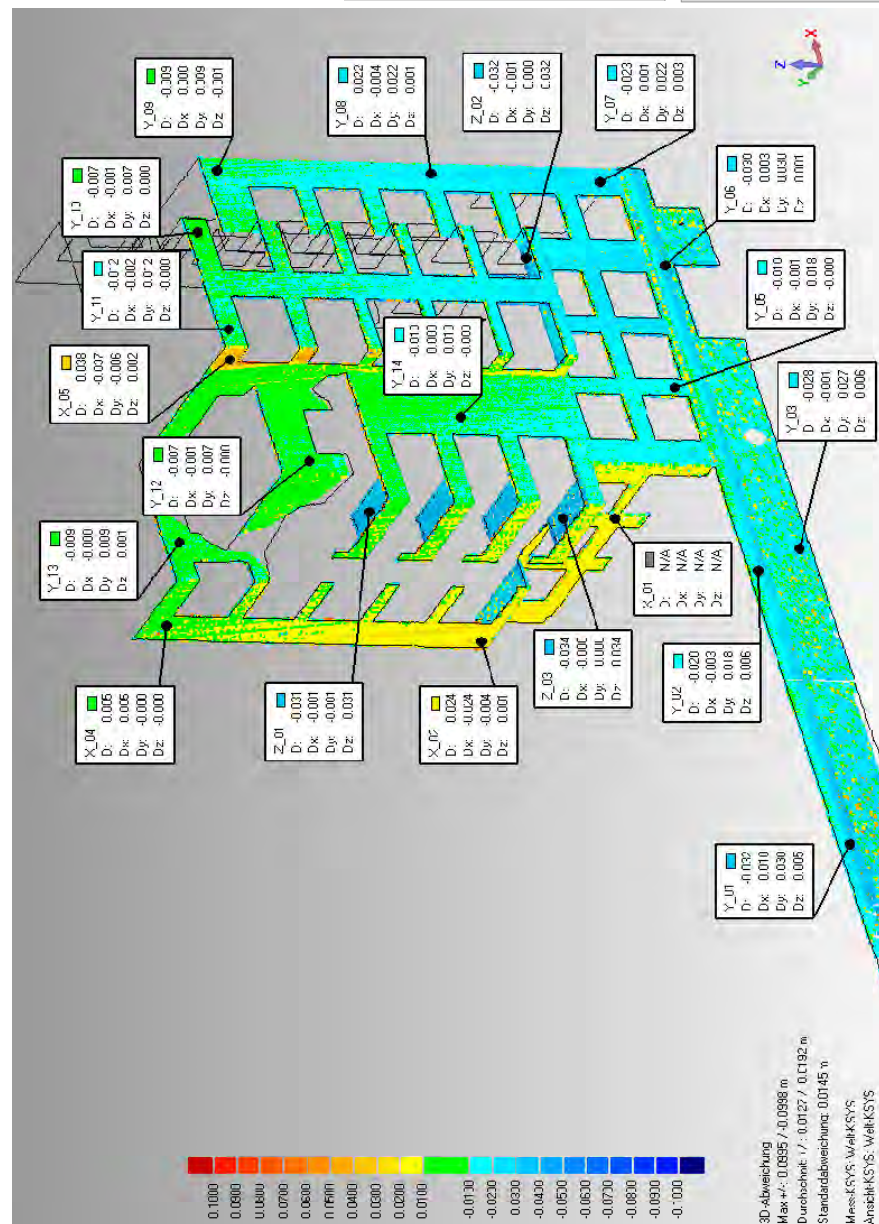
Object C Differences: Ref. / Line 2 - QINSy Postpro. INS



Object C Differences: Ref. / Line 2 – RiPROCESS Recalib.



Object C Differences: Ref. / Line 3 - QINSy Postpro. INS



3D-Abweichung

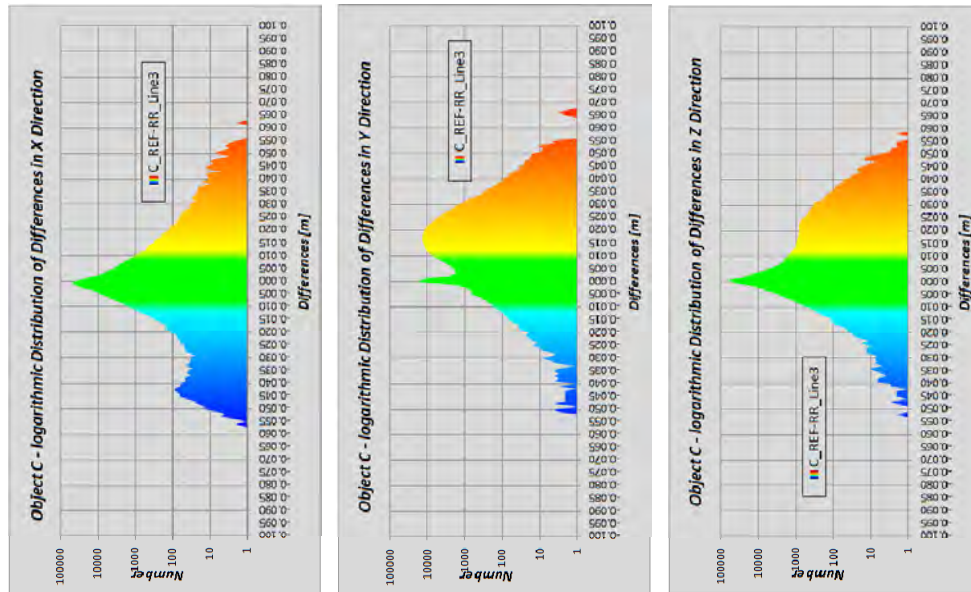
Max +/-: 0.087 / 0.0912 m

Durchschnitt +/-: 0.0086 / 0.071 m

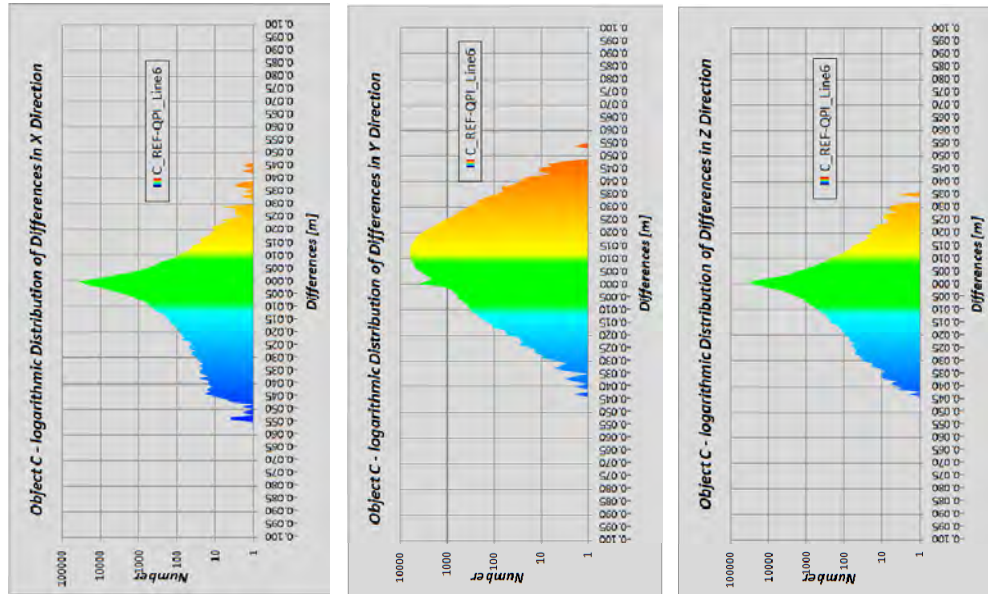
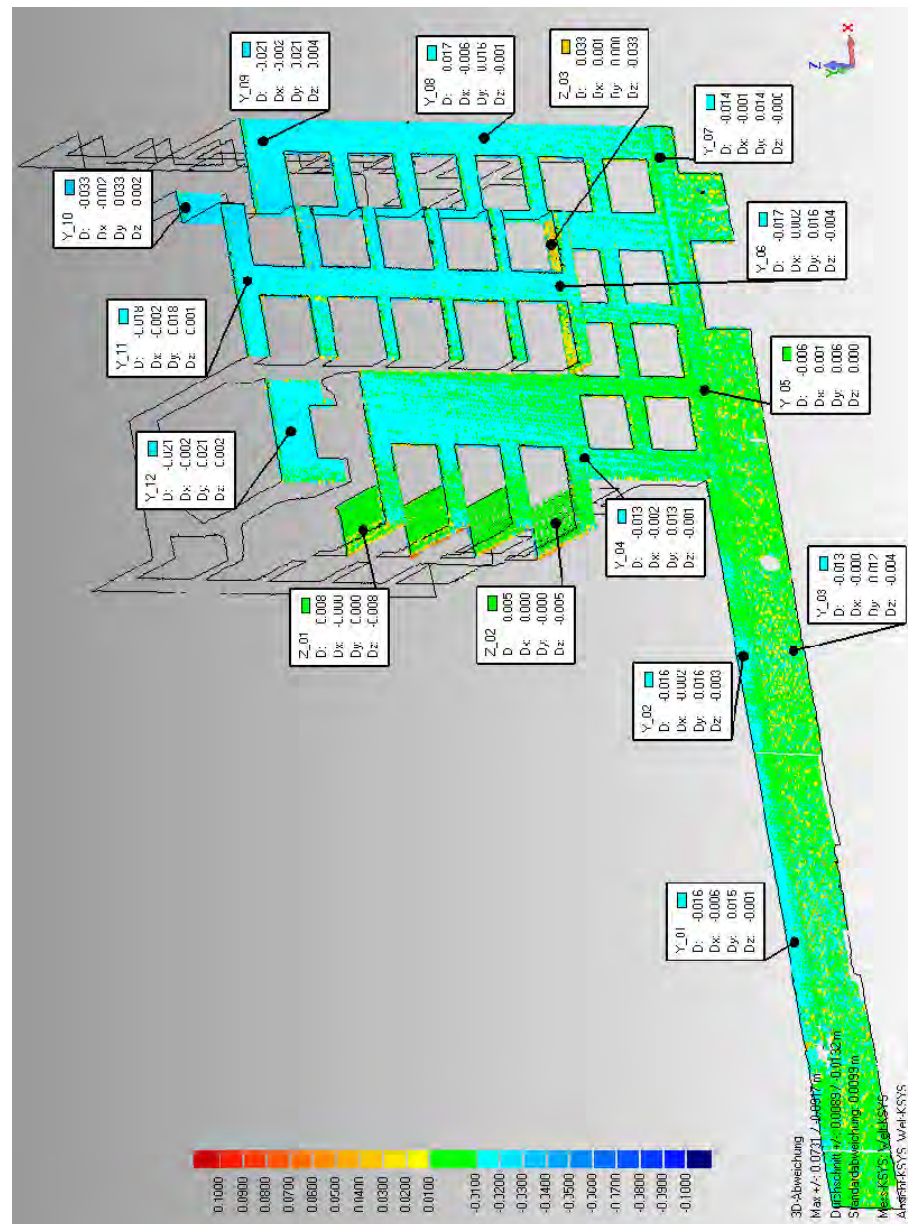
Standardabweichung: 0.0108 m

MassKSYS: VlakKSYS

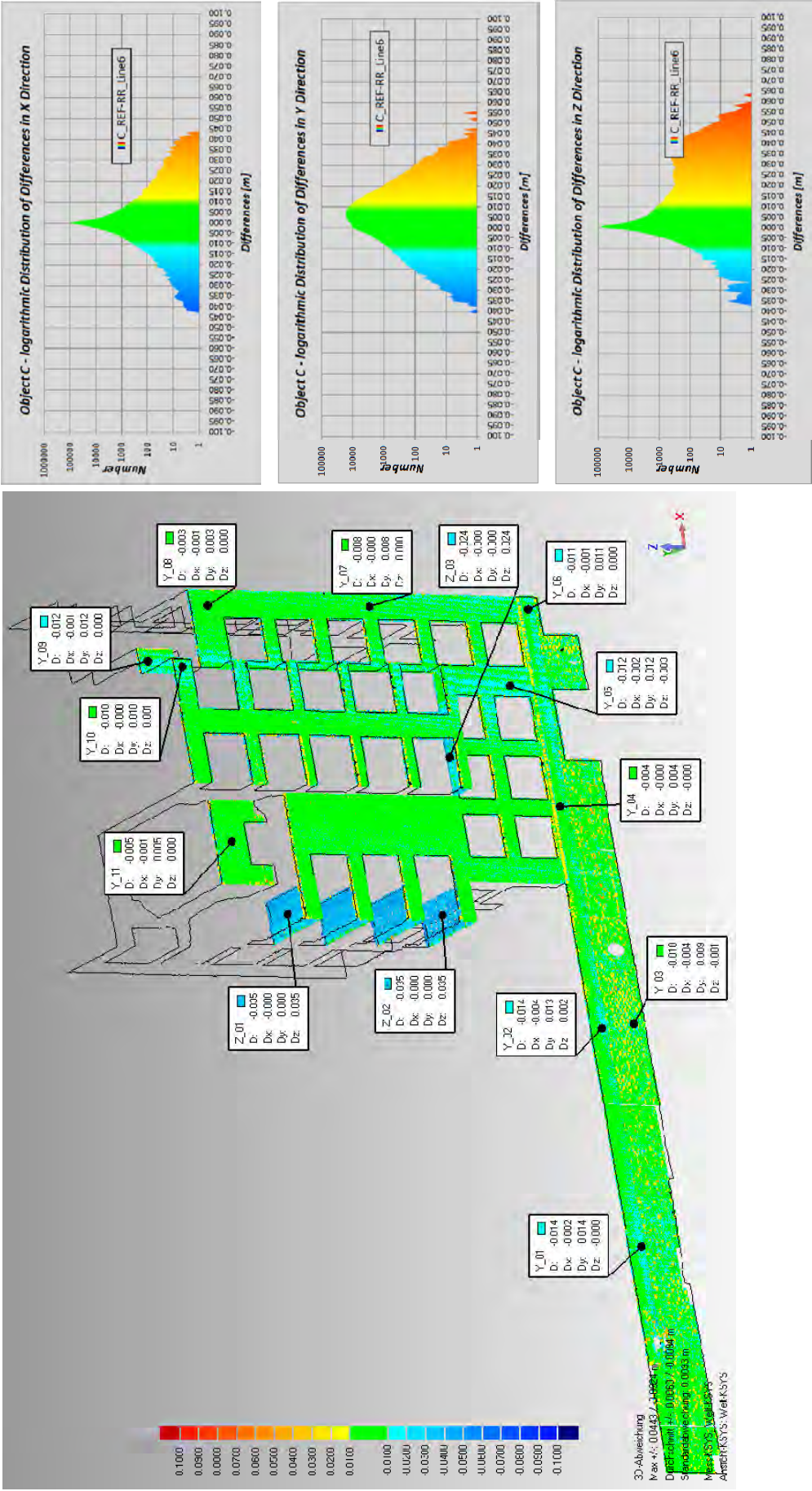
MassKSYS: VlakKSYS



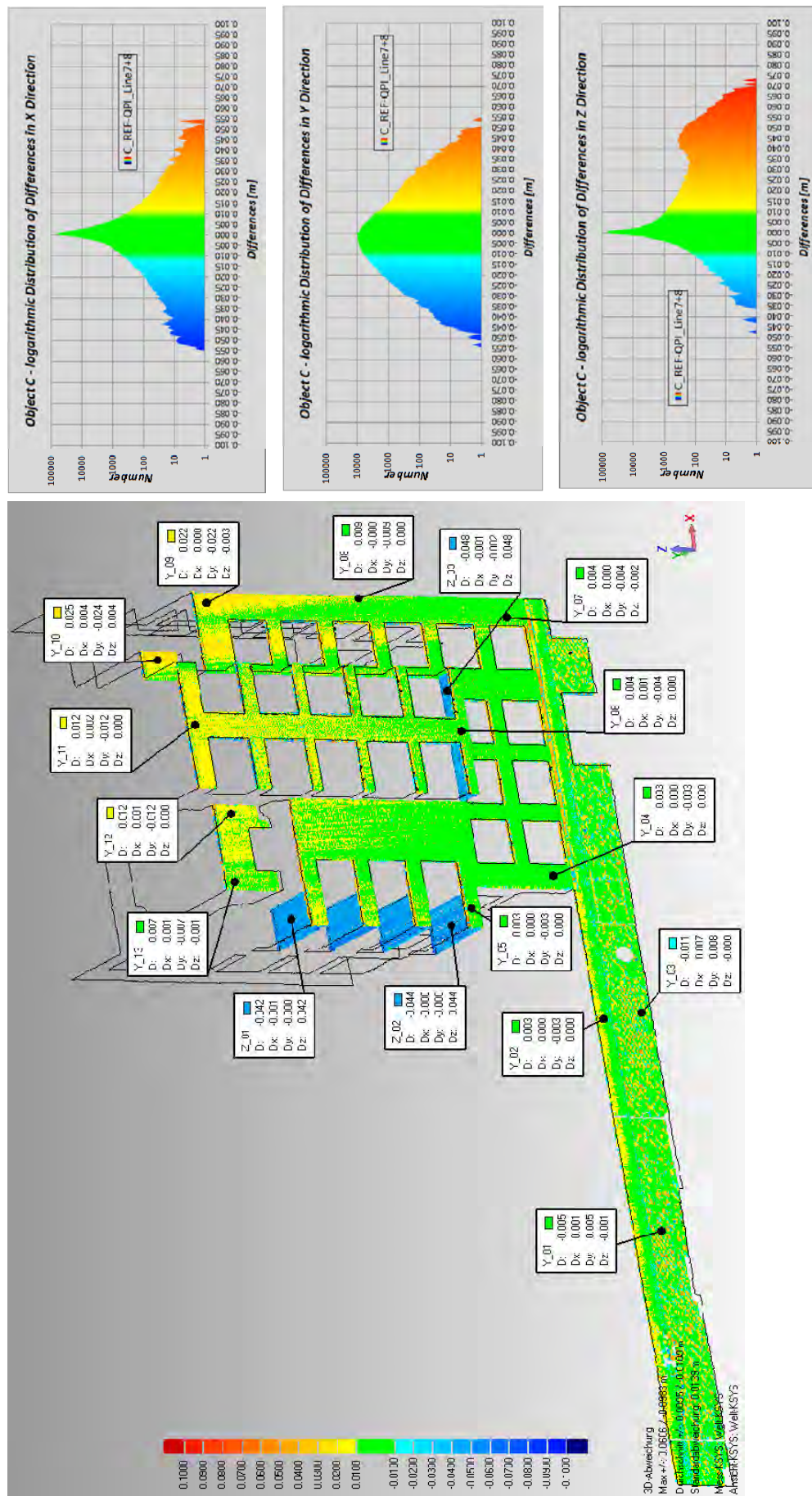
Object C Differences: Ref. / Line 6 - QINSy Postpro. INS



Object C Differences: Ref. / Line 6 – RiPROCESS Recalib.



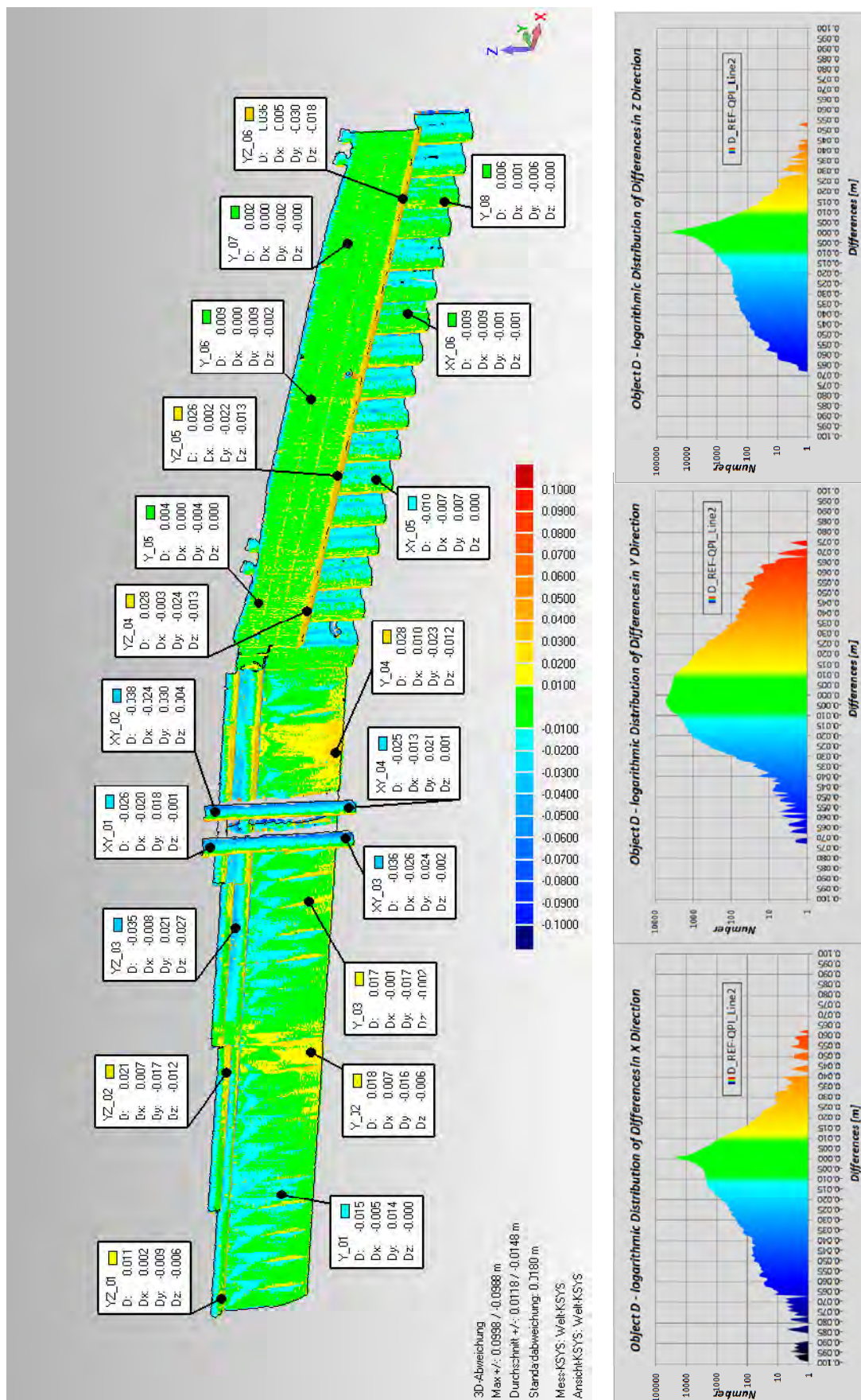
Object C Differences: Ref. / Line 7+8 - QINSy Postpro.



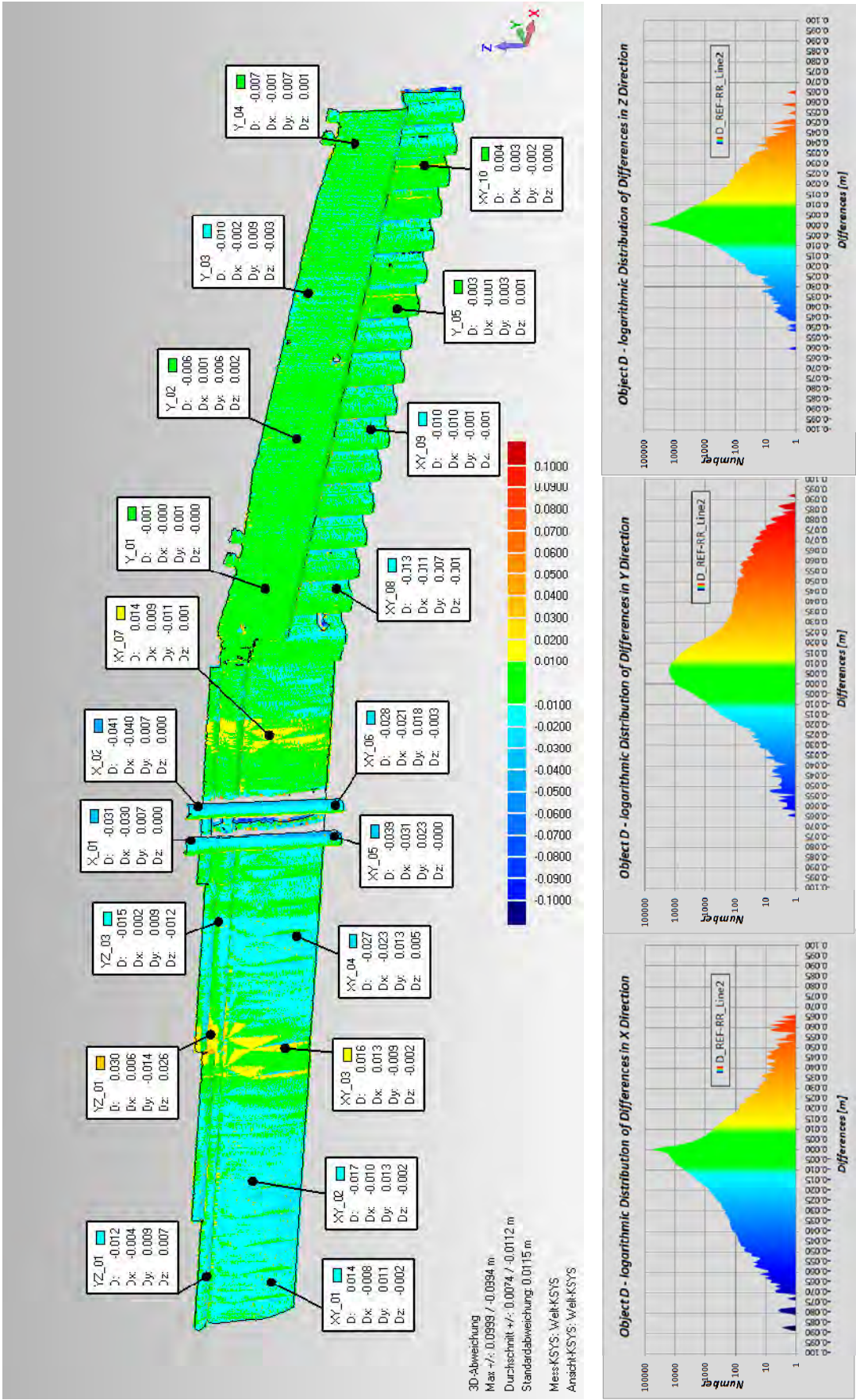
Object C Differences: Ref. / Line 7+8 – RiPROCESS



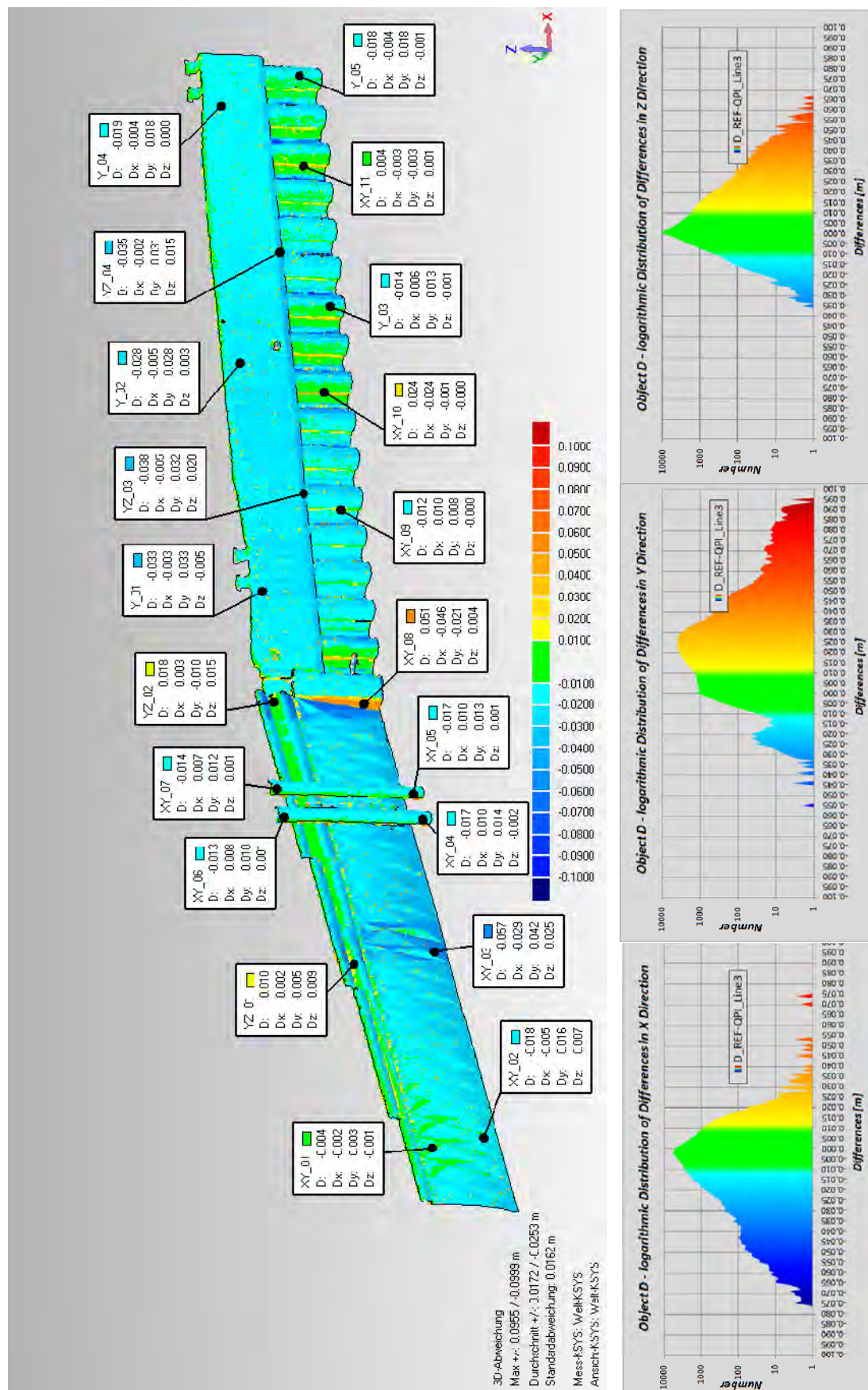
Object D Differences: Ref. / Line 2 - QINSy Postpro. INS



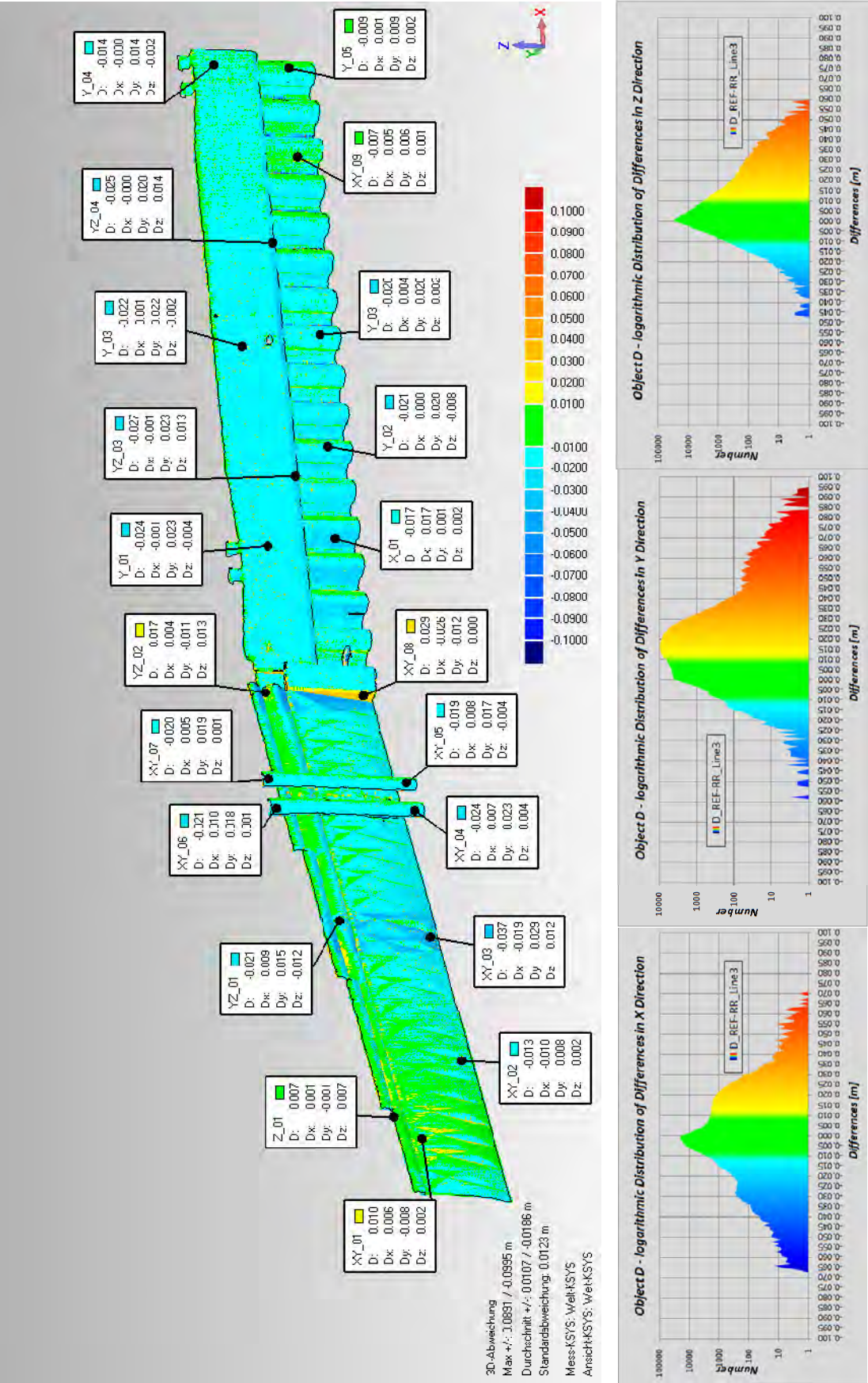
Object D Differences: Ref. / Line 2 – RiPROCESS Recalib.



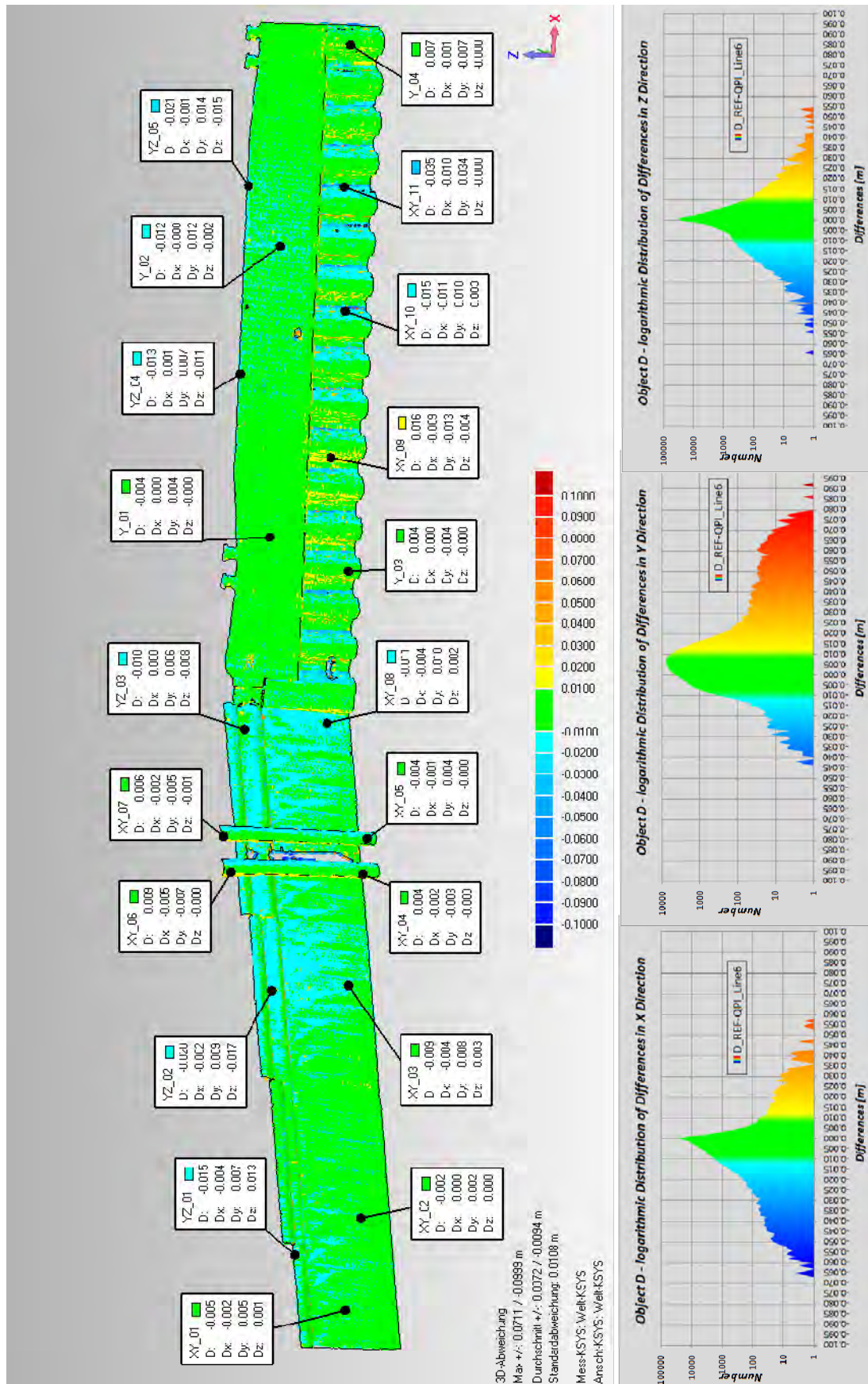
Object D Differences: Ref. / Line 3 - QINSy Postpro. INS



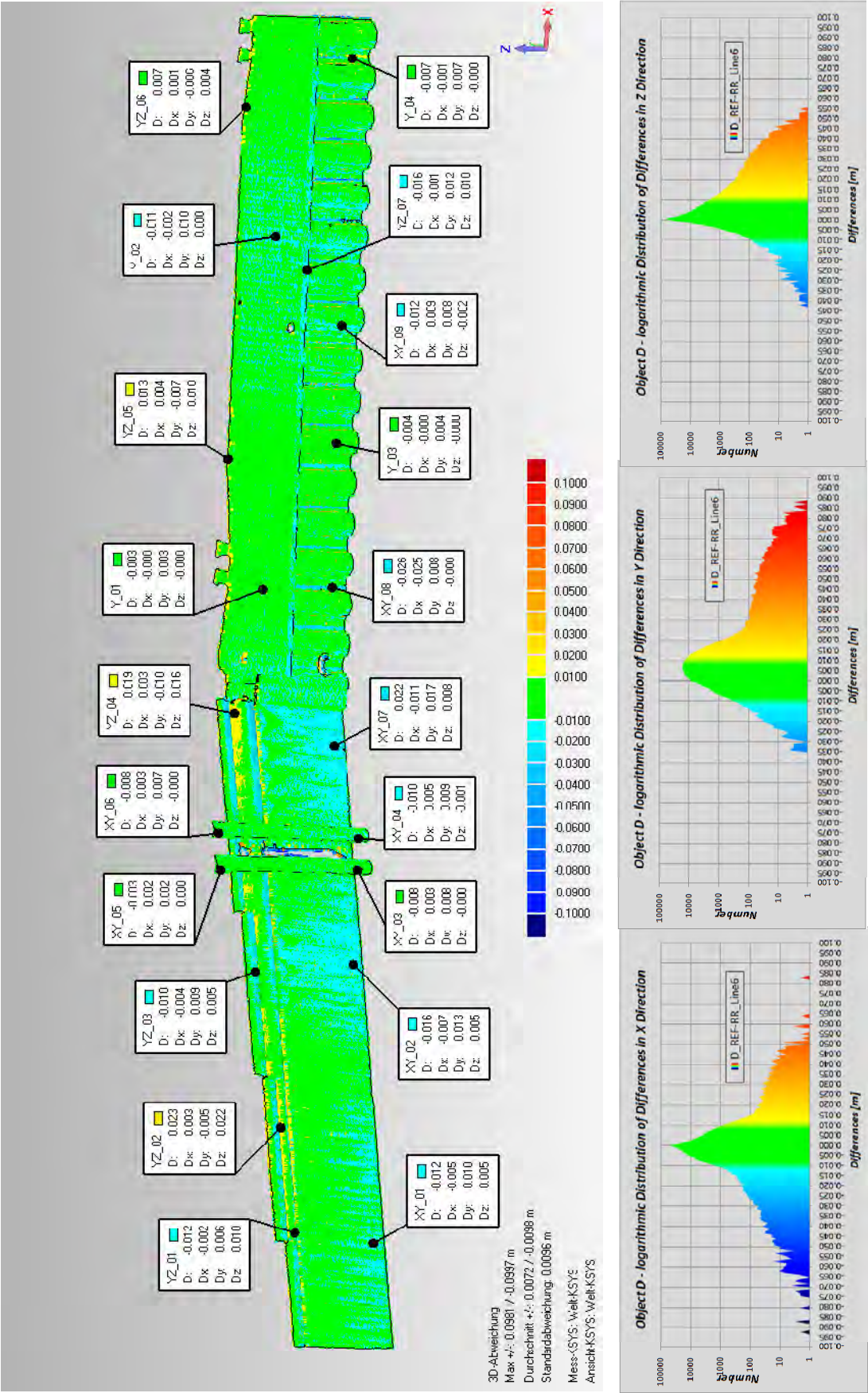
Object D Differences: Ref. / Line 3 – RiPROCESS Recalib.



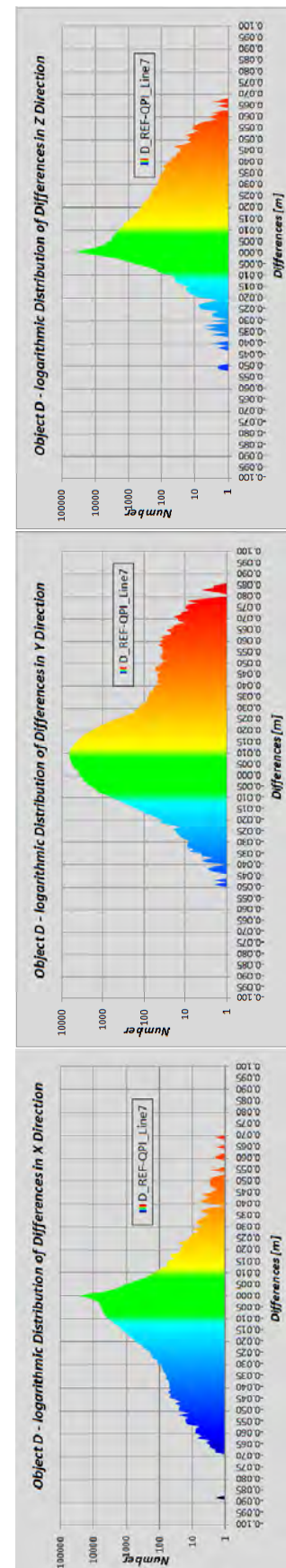
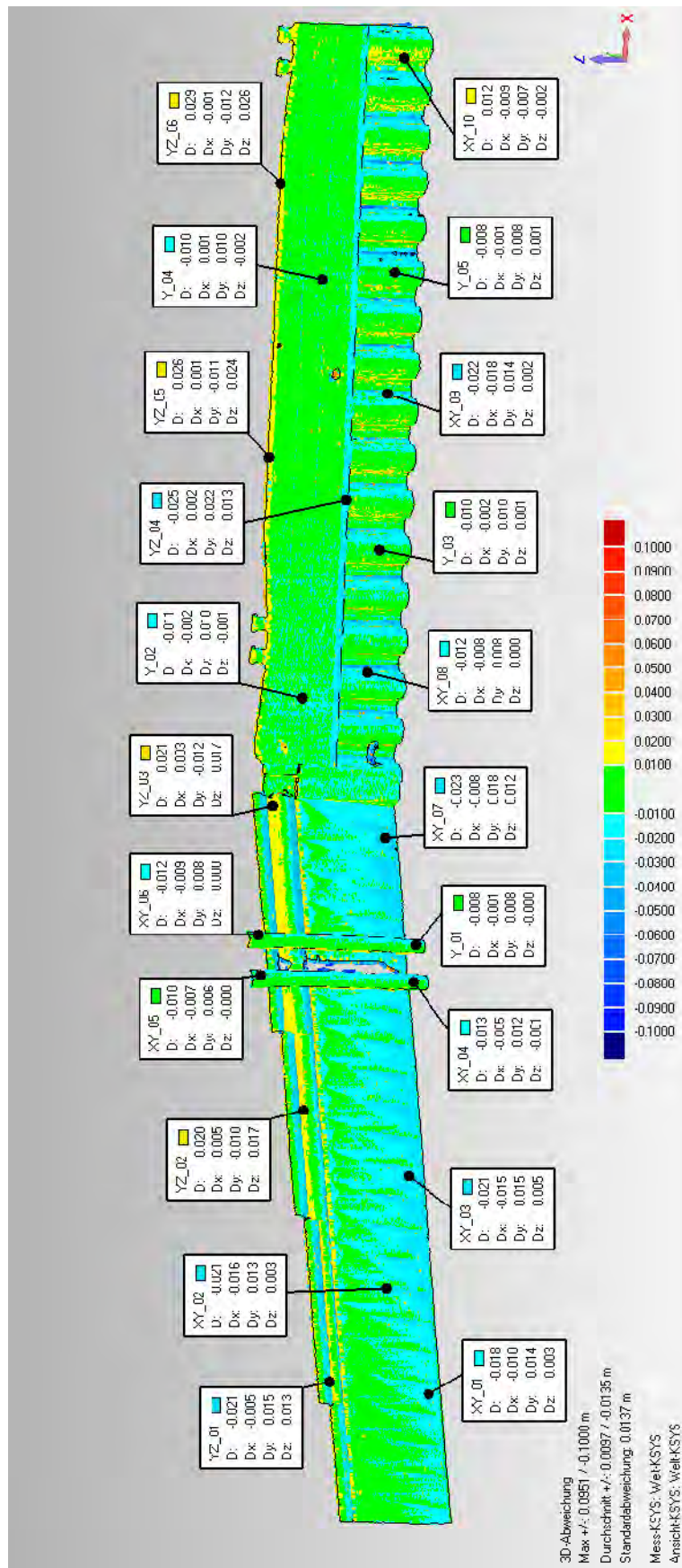
Object D Differences: Ref. / Line 6 - QINSy Postpro. INS



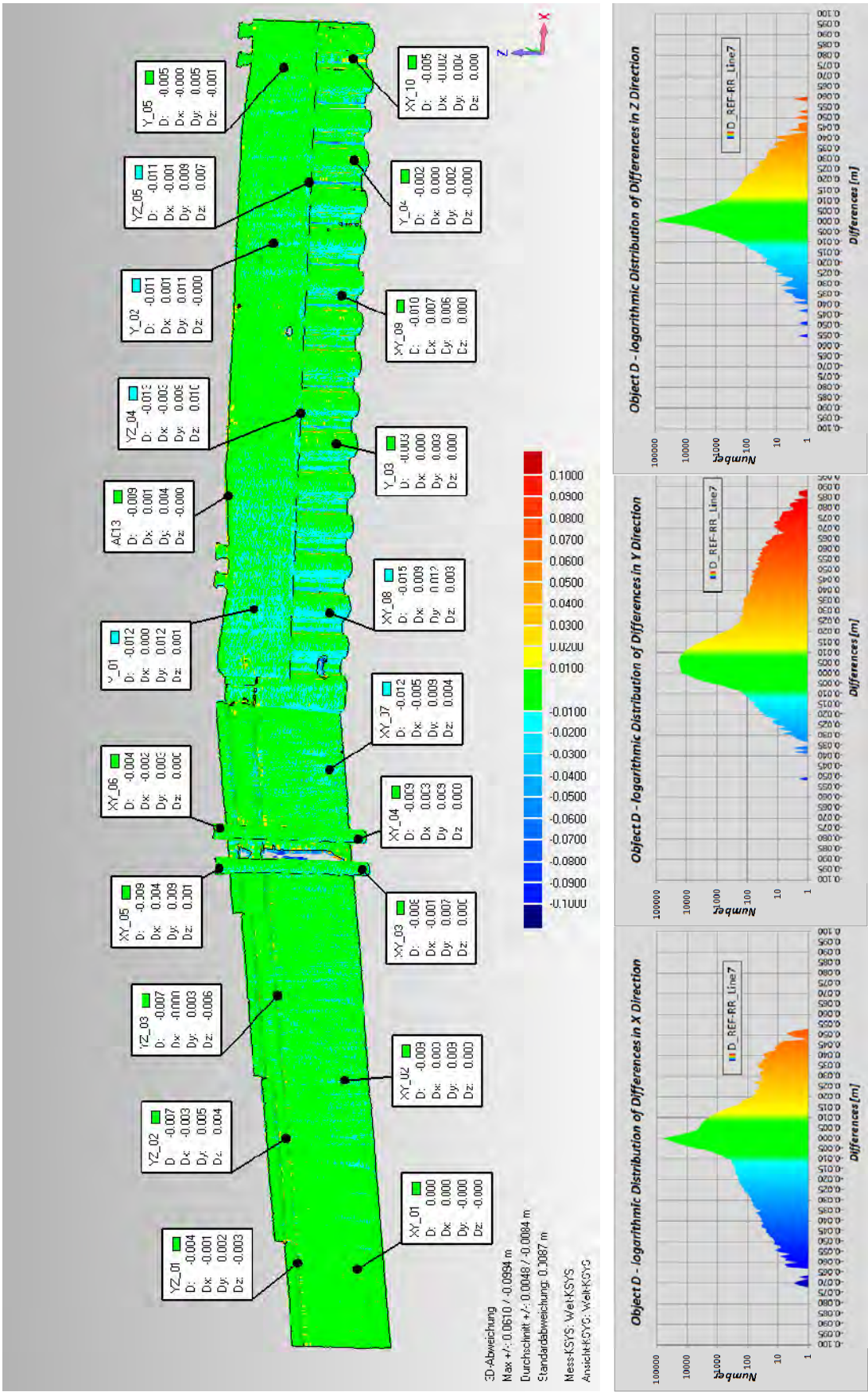
Object D Differences: Ref. / Line 6 – RiPROCESS Recalib.



Object D Differences: Ref. / Line 7 - QINSy Postpro. INS



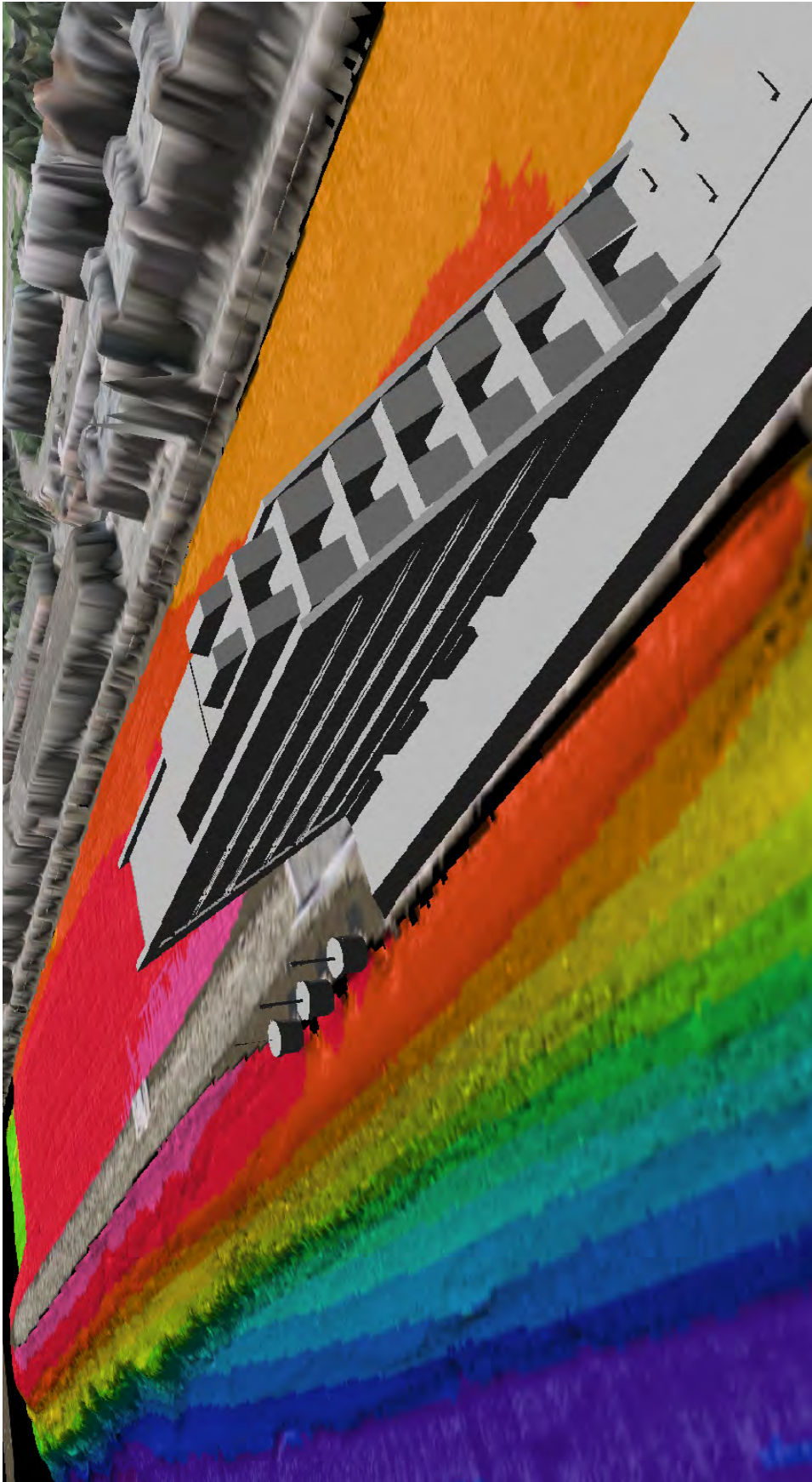
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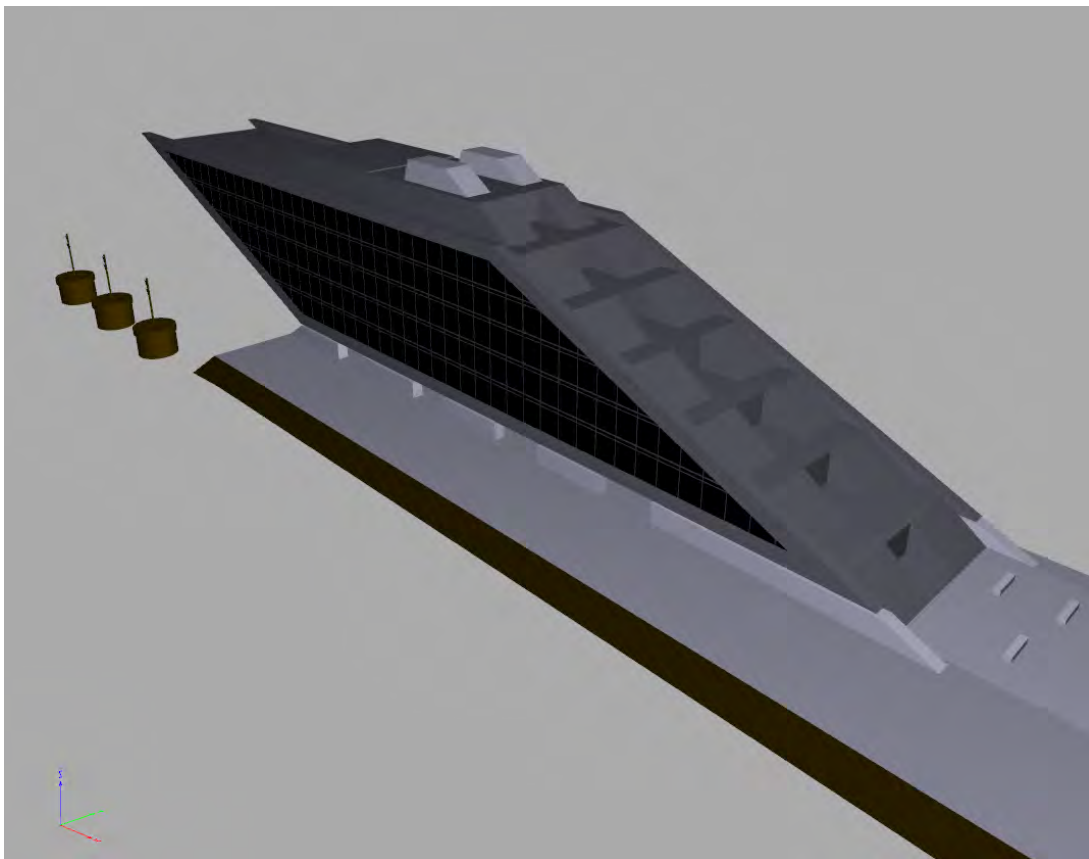
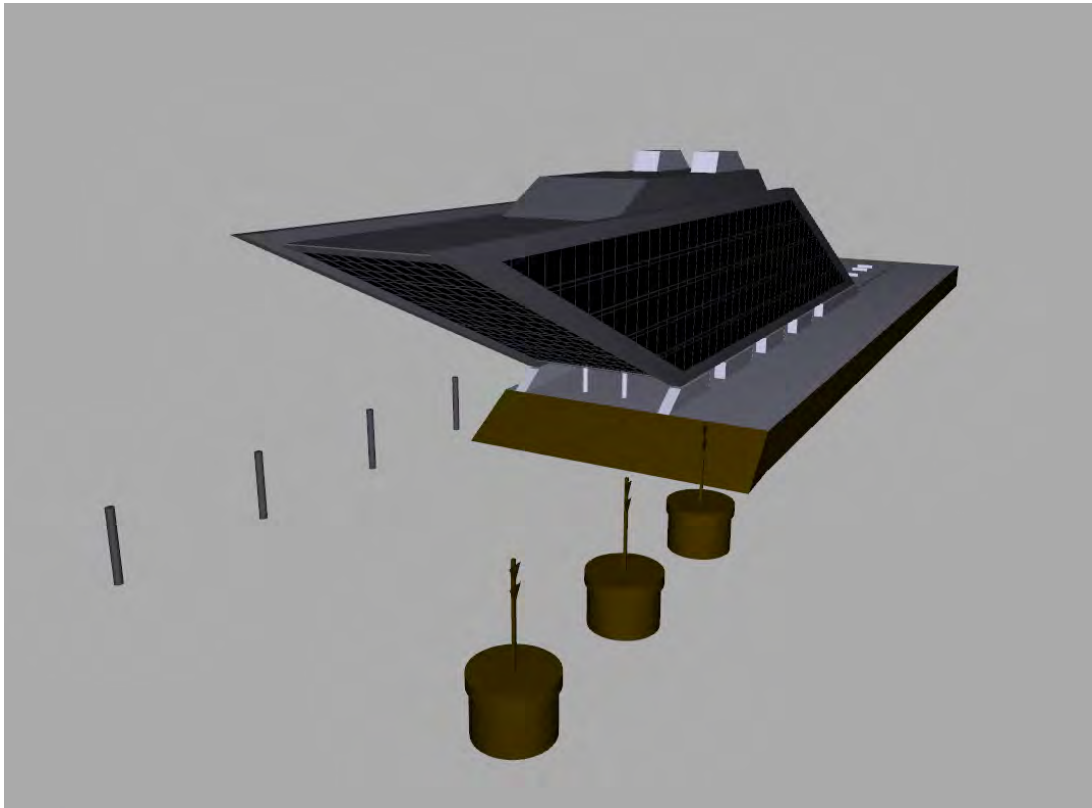
Appendix A-7

Product “Dockland” – Object of 3D Port Model

Object “Dockland” – 3D Model+Bathymetry+Ortho-Photo



Object “Dockland” – 3D Model



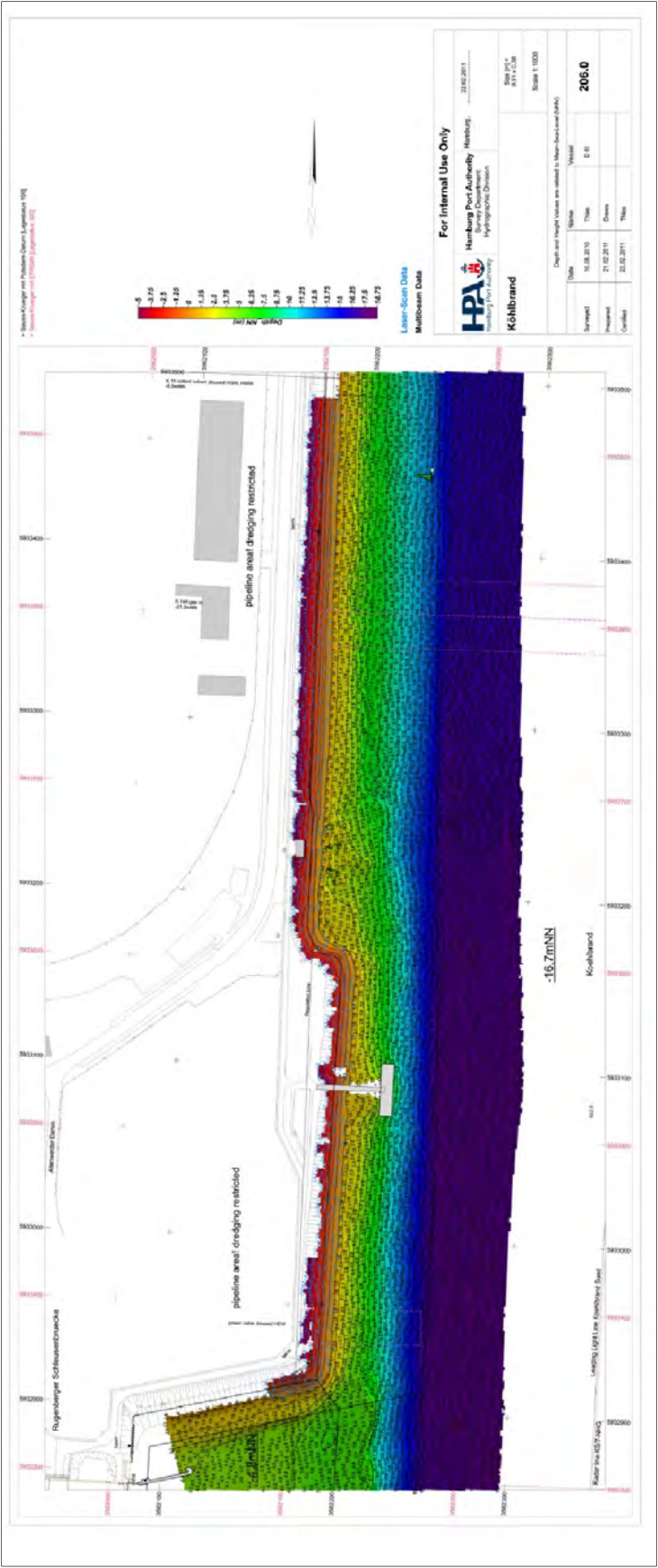
Appendix A-8

Product “Koehlbrand” – Bathymetric Chart

Object “Koehlbrand” – Bathymetric Chart



Object “Koehlbrand” – Bathymetric Chart + Grid



Appendix A-9

Product “Grasbrookhafen” – ENC

Object “Grasbrookhafen” – ENC

Object “Grasbrookhafen” – ENC in ECDIS Application

