AUTOMATED GEOMONITORING

with low-cost GNSS sensors

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Alberding GmbH

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Overview

Alberding GmbH

Alberding A07 Monitoring System

Applications

Outlook

Alberding GmbH - History

- **1994** – Founded by Jürgen Alberding as GeoSurvey GmbH
  → *Distribution of Trimble Geospatial systems*
- **2003** – Start of own GNSS infrastructure solutions in Wildau
  → *Separation of Trimble sales and own developments*
- **2009** – Sale of GeoSurvey GmbH to Trimble („AllTerra“)
- **2019** – KMU 12 Employees (11 engineers)
  → *Independent from GNSS receiver manufacturers*

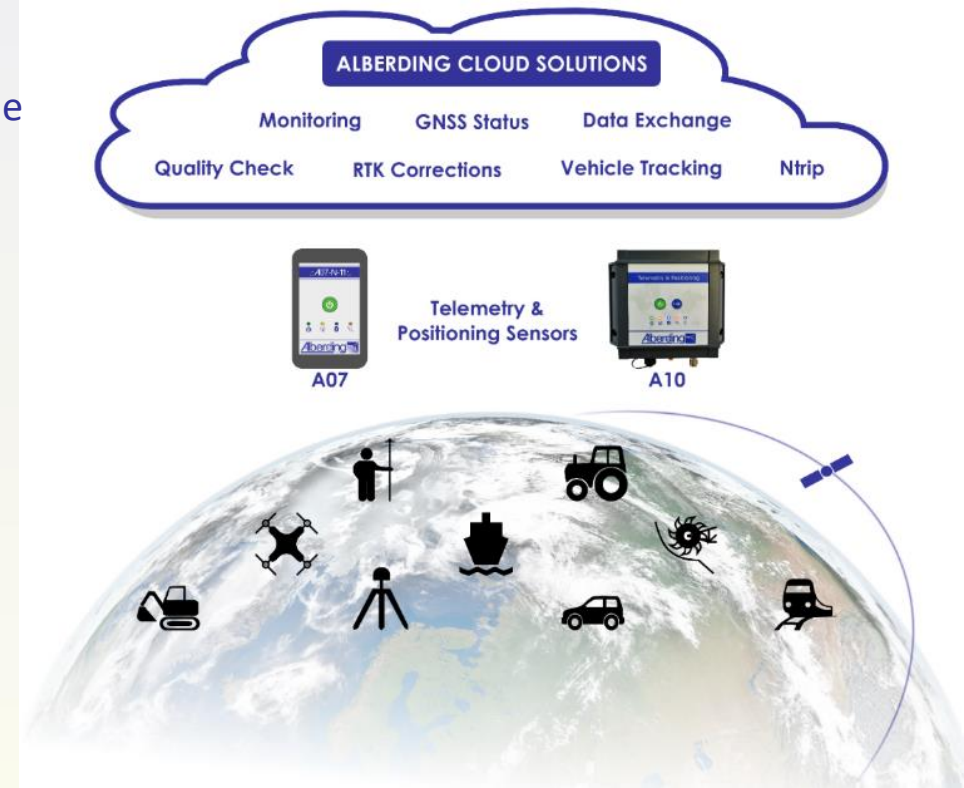
Range of services (portfolio)

Adaptable **software, sensors, systems and services**
for automated applications of precise (mm-cm) satellite based positioning, monitoring and data transmission

Alberding GmbH

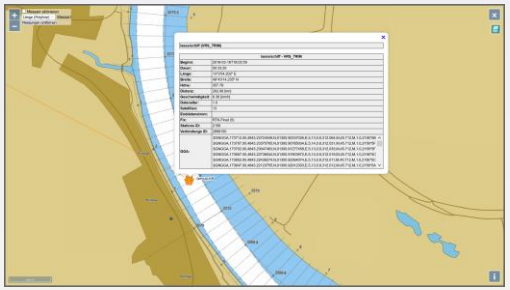
System approach of Alberding GmbH

- Adaptable Web-based server software for (GNSS-) position based **applications** and **services** (Cloud solution)
- Mobile positioning solutions adapted to the customer needs in terms of data flow, special calculations , sensor integration
- „Intelligent telemetry & positioning sensors“ (Alberding A07 and A10) for **automated operation** in the field with
  - High integration level
  - Standalone operation
  - Flexible configuration (data flow)
  - Use of low(er)-cost GNSS receivers
- **Advantages of this approach**:
  - Attractive sensor prices
  - Automation of solution adapted to the customer needs



Alberding GmbH products

- **Beacon.Net**: DGNSS Infrastructure solution for AtoN service provider
  - Integrity checked DGNSS corrections (pre-broadcast monitoring)
  - Combination of DGNSS/RTK and waterway information



- **Alberding Ntrip Caster**: RTK corrections via Internet
  - Mass use of data (mount points, users)
  - Map display of user positions (WMS, Sentinel maps, iECDIS, etc.)

- **AQC**: Quality control for GNSS services
  - CheckStream, RTK check, InspectRTCM
- **MaPos**: Software for machine positioning
  - Positioning of excavators with GNSS-RTK receivers and tilt sensors

- **AGIS**: Field software for data collection and stake out
  - Surveying tool on digital maps, integration of photos
- **Alberding Monitor**: Geomonitoring solution
  - GNSS monitoring (Postprocessing, Near-Online Processing, RTK, PPP)
  - Other sensors (total stations, geotechnical sensors, etc.)

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Use of GNSS sensors for geomonitoring

Advantages

- Free of charge
- Worldwide available
- 24 hours / 365 days
- High 3D accuracy (cm - mm)
- High data rate (up to 50 Hz)
- Weather independent
- Robust sensors
- No line of sight needed between reference station and sensor

Disadvantages

- Measurement of single points
- Geometric height information
- Need to see the satellites (free sky)
- No guaranteed availability (military)
- Need of power and data transmission at the monitoring sensors
- High prices for GNSS sensors with carrier phase measurements
- Combination of different components (processor with software, modem and GNSS-Sensor) for automated operation

Addressed by Alberding A07

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Alberding A07 monitoring system

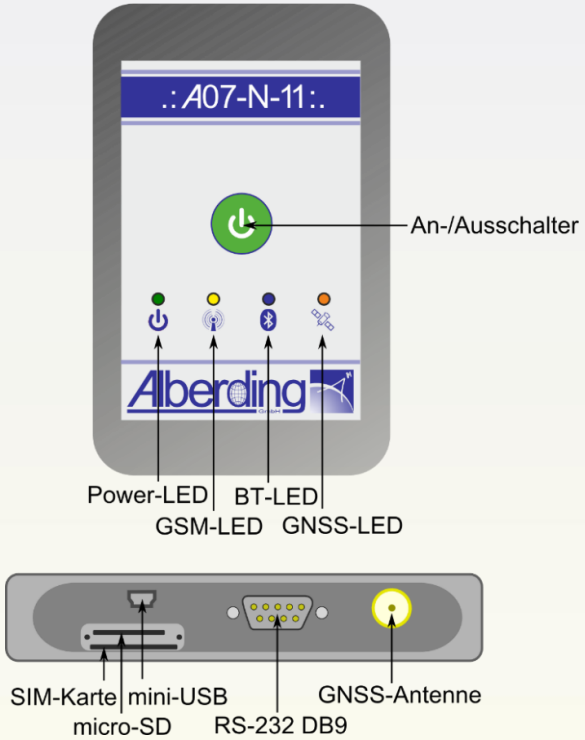
1) **Use of low-cost GNSS modules with code and carrier phase measurements („raw data“)**
   - Low(er) price
   - Low(er) power consumption
   - Small(er) form factor

2) **Hardware integration of main components**
   - GNSS Module (external GNSS antenna)
   - Internal memory for data logging
   - GPRS modem for the data transfer to the server
   - Processor with **Alberding data management software**

3) **Easy installation at the monitoring site**
   - Pre-configuration with the Alberding config-tool
   - Press a „single button“ or connect to power to start

4) **System extension via USB or serial port**
   - Support of external data communication (radio modem)
   - Logging of external sensor data (i.e. tilt sensors)

5) **Complete system**, consisting of
   - A07-MON sensors in the field
   - Alberding Monitoring Software at the server (Cloud)

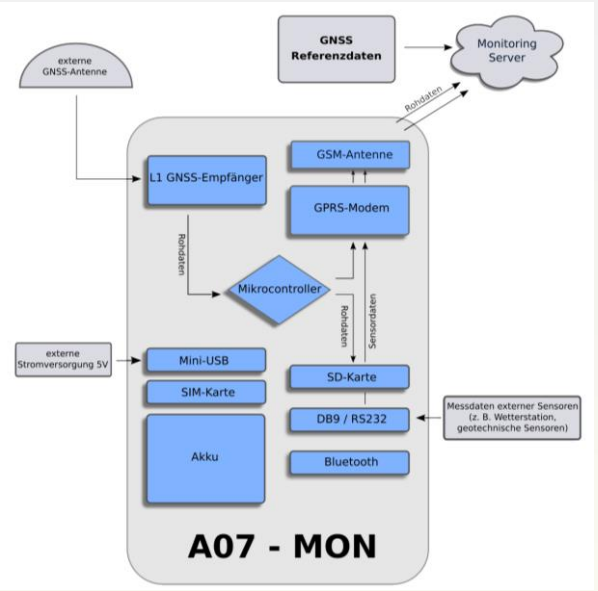


Automated geomonitoring with the A07-MON sensor




The integrated processor and the Alberding data management software in the Alberding A07-MON sensor are the key components for the automation of the monitoring process in the field

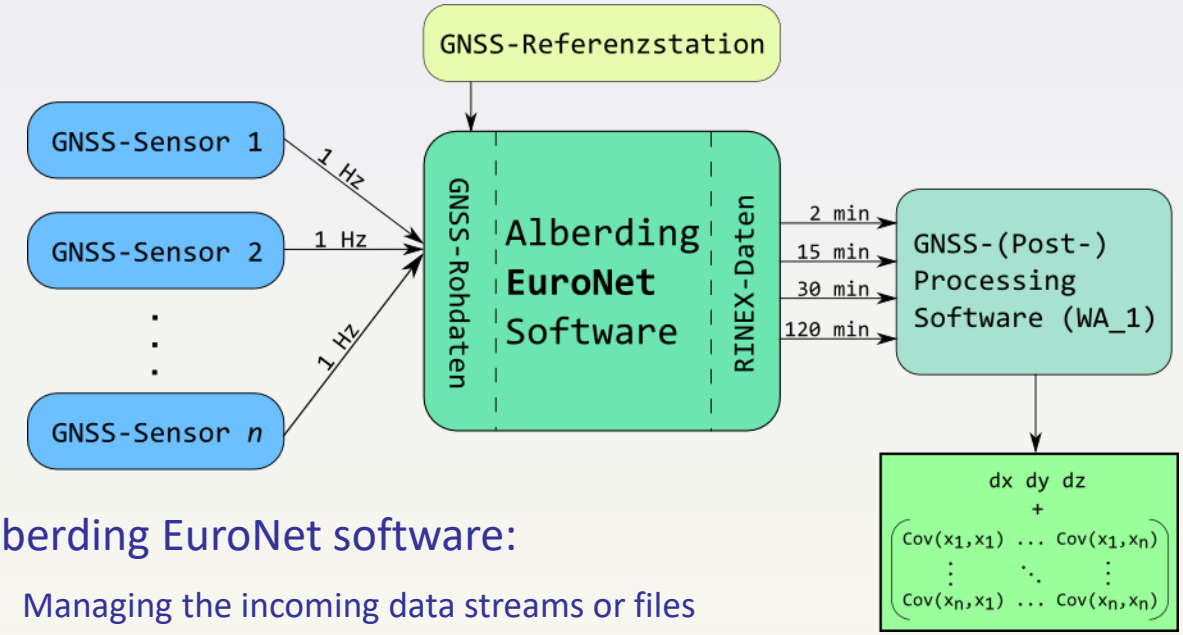
- Automated data logging of GNSS raw data in the sensor
  - Logging rate (i.e. 5 or 15 seconds)
  - elevation mask (i.e. 15 degrees)
  - File size (i.e. 1 hour)
  - Timer functionality for logging intervals (i.e. 4 hours/day)
- Automated logging of internal sensor parameters
  - Capacity of the internal battery
  - Field strength of the GPRS modem
- Automated logging of external sensor data
  - Weather station
  - Tilt sensors
  - Geotechnical sensors
- Automated data transfer of the GNSS raw data and external sensor data
  - File transfer to the server (i.e. every hours)
  - Real-time data streaming (battery life time)



Data flow in the A07-MON sensor

Automated GNSS processing at the server

Autonomous operating A07 monitoring system in the field powered by solar panels



Alberding EuroNet software:

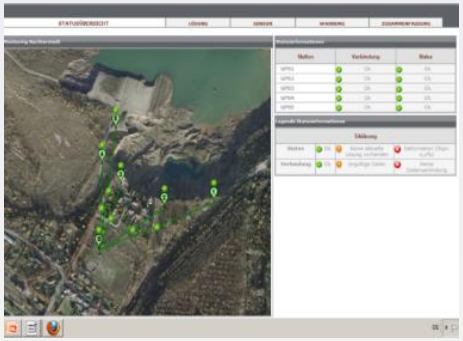
- Managing the incoming data streams or files
- Extracts external sensor data from GNSS data
- Converts GNSS raw data in RINEX for multiple processing intervals (i.e. 1h, 4h, 24h)
- Supports other GNSS raw data (Trimble, Leica, Topcon, Septentrio, NovAtel, etc.)

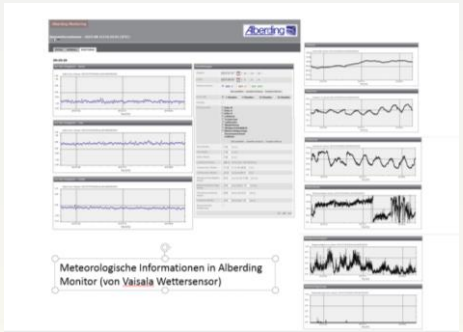
Near-online processing is done by a 3rd party software

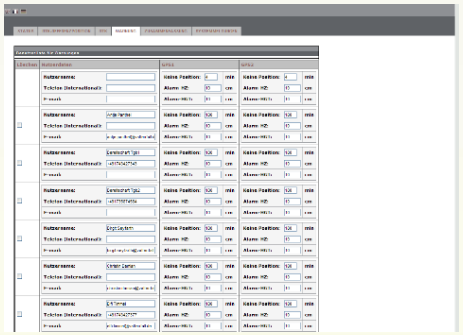
- WA2 from Prof. Wanninger (standard)
- Other packages (i.e. RTKlib) supported

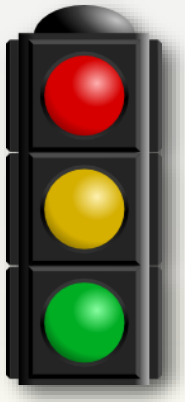
Alberding Monitoring Software

- Graphical overview on a digital map with status information (access via web browser)
- Time series plots
  - Coordinates from the post processing software
  - Coordinates from RTK measurements
  - External sensor data
  - „Sensor parameters“
- Alarming when exceeding thresholds
  - E-Mail and SMS lists for dedicated persons
  - Visual or acoustic alarms
- Reporting and data exchange
  - PDF and CSV output
  - FTP push to other servers
  - Archiving and storage









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Example: Monitoring of land slides (Germany)

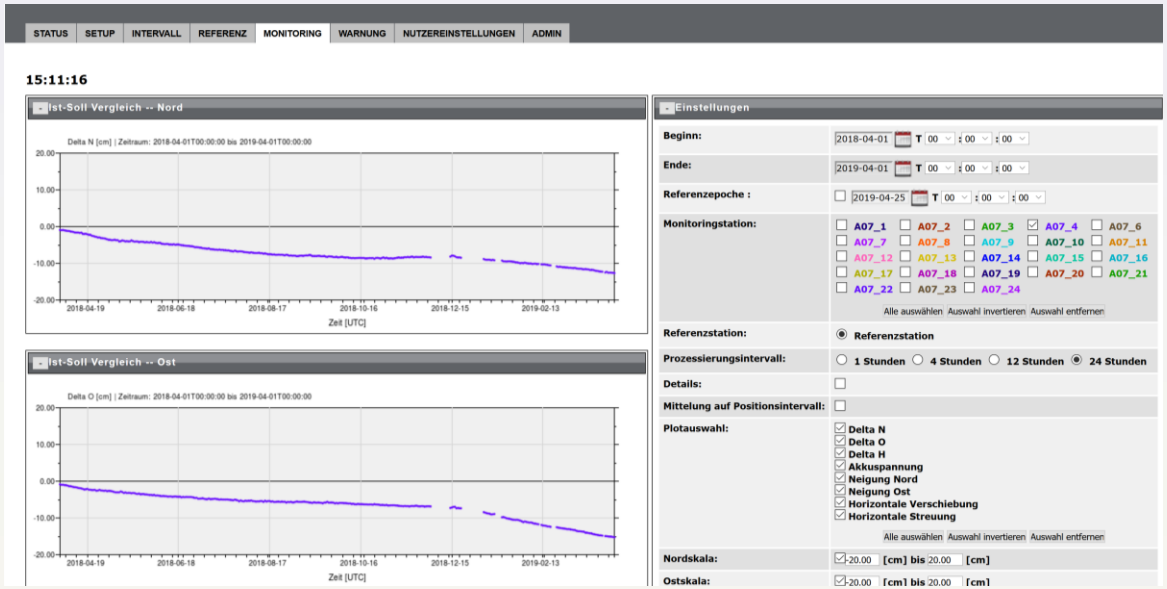
Installation of the A07-MON in a weather box at a pole with pre-configured sensors

Power: Autonomous operation with solar power (2 x 30W panels)

Data transfer: File transfer via mobile Internet (1h)

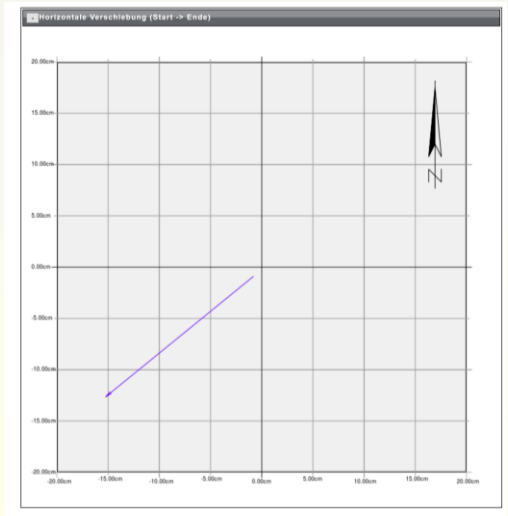
Processing: Alberding Monitoring Software on an Internet server platform (rental model)

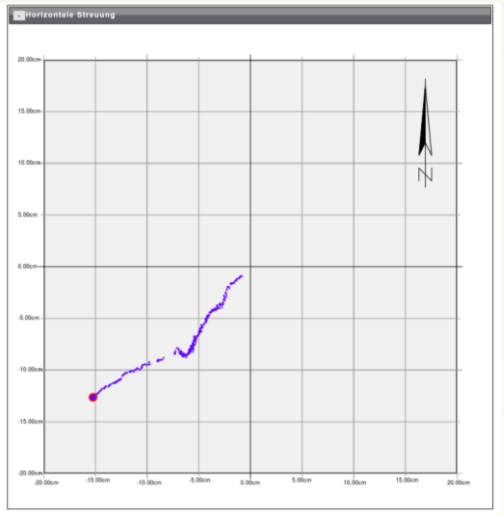
Example: Land slide from 01.04.2018 – 01.04.2019

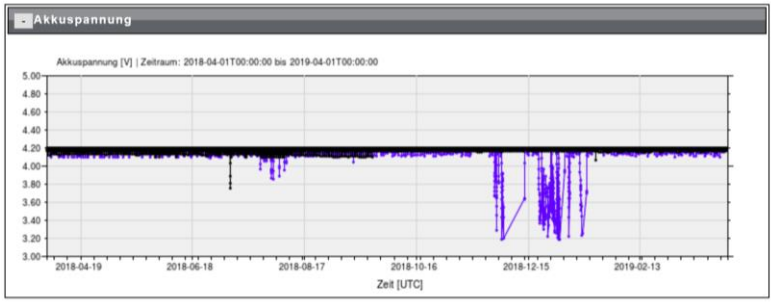


Movement of Sensor 4 over the period of 1 year (01.04.2018-01.04.2019):

Pict.1: Change in the North- and East component
Pict.2: Vector from start to end
Pict.3: Horizontal movement
Pict.4: Battery voltage (solar power)







Example: Monitoring of a bridge (Netherlands)

Last Friday Strukton Maatvoering & Monitoring completed a Factory Acceptance Test for the GNSS monitoring system on the Botlekbridge nearby Rotterdam. The results were satisfactory and within the specifications of the specified sub-cm accuracy. When the system is installed on the towers of the Botlekbridge sub-centimeter deformation can be measured. minder weergeven

FAT test with total stations (Strukton)

Installation of 6 x A07-MON on the pillars and 2 x A07-MON sensors at the reference stations (west and east of the bridge)

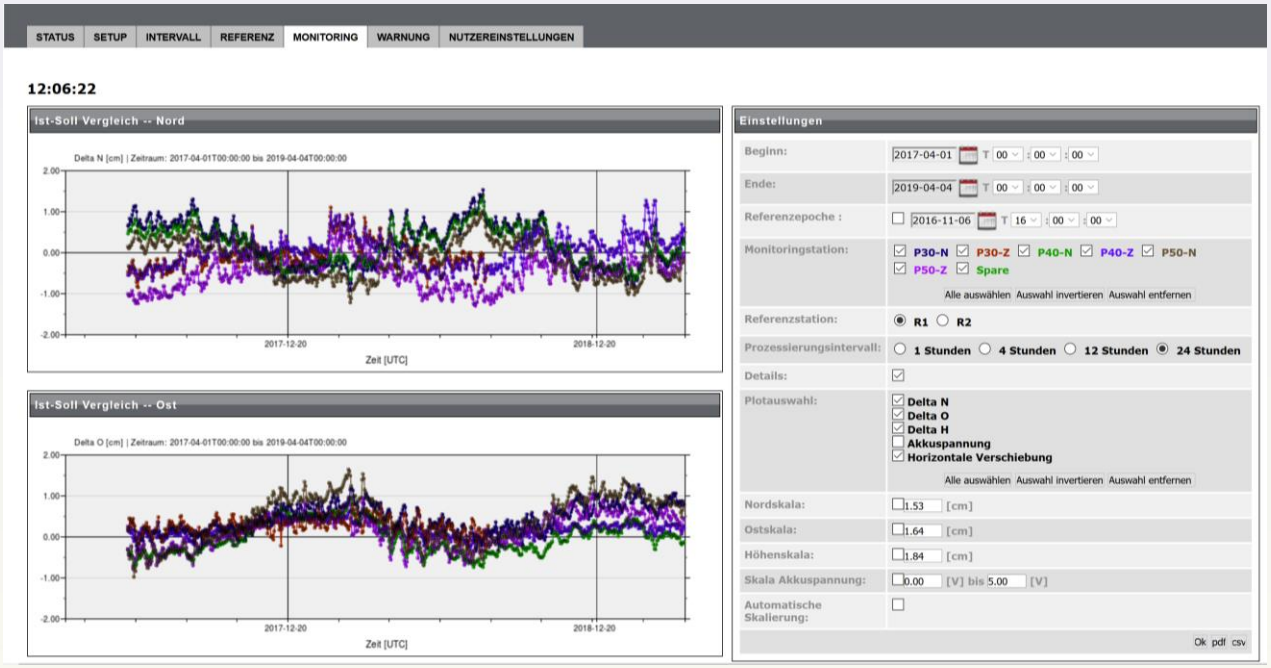
Data transfer: Mobile Internet

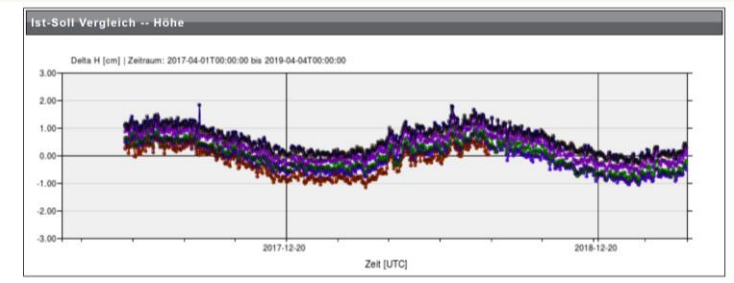
Power: 220V available at the bridge

Processing: Alberding Monitoring Software at a customer PC with Internet access

Partner: NavSol
Gerrit van der Vliet

Monitoring of a bridge (01.04.2018 – 04.04.2019)



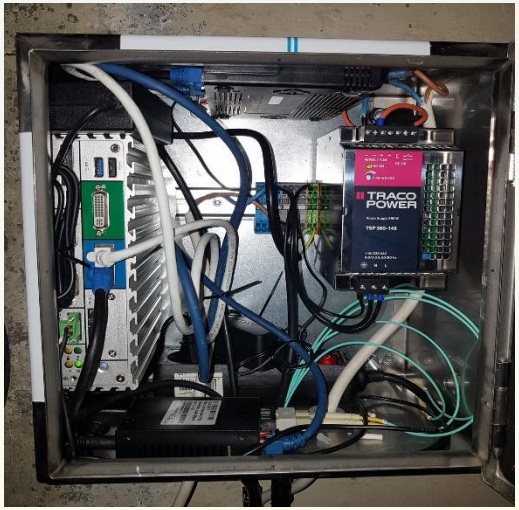


Horizontal components: (+/- 1cm)

Height: (+/- 1,5cm)

Example: Monitoring of a dam (Kirgistan)

A07-MON sensorbox



Master box with processing unit (PC)

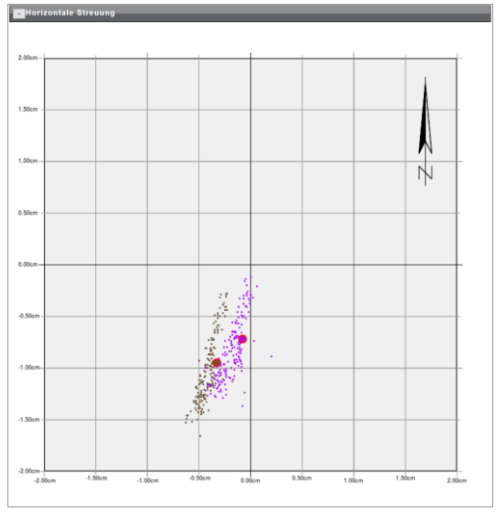
Installation of 13 x A07-MON sensors at the dam and 2 x A07-MON sensors as reference stations (west and east of the dam)

Data transfer: Ethernet (RS232 converter)

Power: 48V at the dam

Processor : Alberding Monitoring Software on an embedded PC at the dam

Monitoring of a dam (15.10.2018 – 15.04.2019)



Picture above: Variation in the North component - (up to 1,5cm in 6 month)

Picture left: Horizontal variation of sensor 6 and 7 (in 6 month)

Summary: Alberding A07 monitoring system

- Use of low-cost L1 GNSS modules with raw data (code and carrier phase)
  - Low price, low power consumption, small form factor
- Integration of a GNSS module, a modem and memory in one sensor
  - One power management for all components
- Integration of an embedded PC and data management software
  - Requirement for process automation in the sensor:
    - GNSS and external sensor data logging
    - Data transfer to the server
- Automated Processing at the server
  - Management and conversion of the sensor data
  - Processing of RINEX-Files
  - Visualization and alarming
- Accuracies varies on the observation conditions (satellite visibility, distance to the reference station, multipath, observation time, etc.)
  Assumption: good sat. visibility, short baseline (<1-2km), low multipath
  - 1 hour solution => ~ 1-2cm
  - 4 hour solution => < 1cm
  - 24 hour solution => < 0,5cm

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Summary: Alberding A07 monitoring system

- Most of the A07-MON customers purchased additional systems
  - Accepted monitoring system over 5 years
  - Cheap compared to other “geodetic GNSS sensors”
  - Easy setup due to the config-tool
  - Nearly mo man power needed for system operation
- Customer pay for system extensions (telemetry and positioning)
  - Additional sensors in the field (A07 as a data logger for other sensors)
  - Additional sensors for monitoring (i.e. total station data)
- A07 monitoring system is ideal for
  - Measurement of slow movements with high accuracy over longer time periods
  - Small distances to physical or virtual GNSS reference stations
- **Limitations**
  - Distance to the reference station should be less than 5km
  - A07-MON is not a real-time warning system

  => Move to RTK

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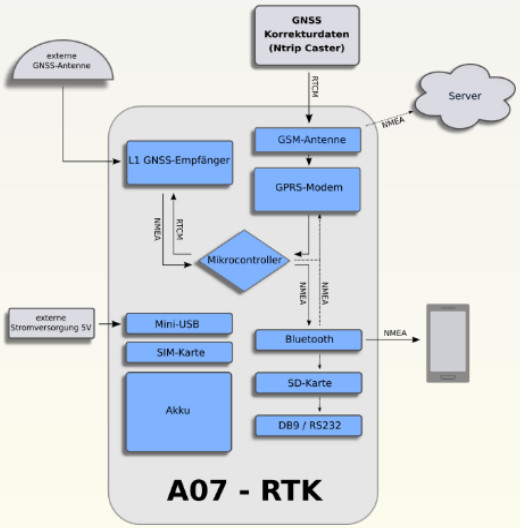
A07-RTK sensor for GNSS monitoring

- First tests with the u-blox M8P GNSS-module (2017)
  - Integration of the RTK module into the A07 sensor
  - Change of the data flow
    - Corrections from the server to the processor
    - RTK positions from the GNSS module to the processor
- Advantage: One system for multiple applications
  - RTK positioning (Surveying, GIS)
  - Data transfer
  - Geomonitoring
- Advantages for geomonitoring
  - No processing of the raw data at the server
  - Real-time alarming possible (after a couple of seconds)
- Disadvantages
  - Compared to A07-MON:
    - Higher requirements on power consumption and
    - data transmission
    - Shorter observation times -> more outliers
  - Compared to dual frequency GNSS:
    - Distance to the reference station
    - Initialisation time and reliability



Data flow in the A07-RTK sensor

Alberding A10 telemetry- and positioning system

Components of the Alberding A10-RTK:

- **L1/L2 GNSS Multisystem** receiver
  - MB-Two (Trimble)
  - NV08C-RTK-M (NVS)
  - Piksi (SwiftNav)
  - F9 Chip (u-blox)
- **Integrated LTE modem**
- Bluetooth module with external antenna
- Integrated memory (MicroSD card)
- Integrated Cortex processor (data management)
- **Optional: Integrated LINUX-Board for application software**

Examples for A10-RTK (MB-Two):

- GNSS Monitorstation (TU Dresden)
- Monitorstation for RTK services (Swisstopo)
- Kinematic positioning (BKG)

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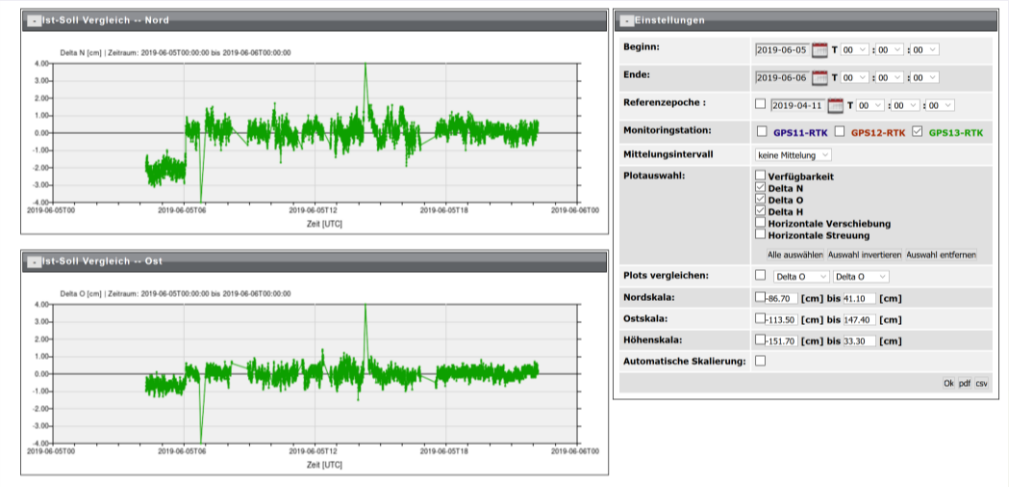
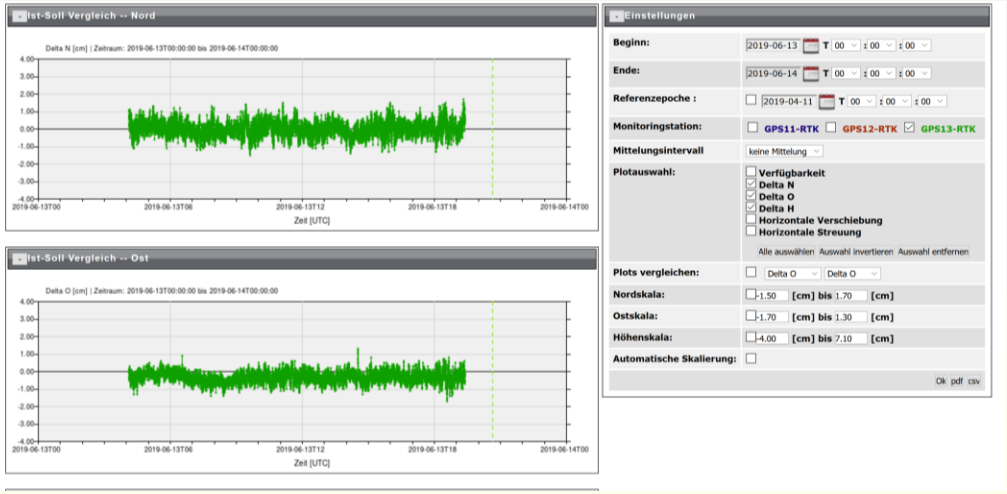
Monitoring with A07-RTK and A-10 RTK (Horizontal)



A07-RTK (05.06.2019)

Outlieres caused alarms



A10-RTK (13.06.2019)

No outliers

Alberding A10 telemetry- and positioning system

Applications for the A10-RTK sensor:

- Geomonitoring
  - Near-Online Processing
  - RTK
- Surveying / GIS
  - AGIS Software
  - RTK monitoring station
- **Integrated LINUX-Board for application software:**
  - SSR2OSR data conversion
  - Support of two IP-Addresses
  - Own processing algorithms
  - Alarming from the A10-RTK
    - Geomonitoring
    - Geofencing
  - Machine positioning
    - RTK + Heading
    - Data transfer
    - Machine data collection (CAN bus)

A10-RTK Rover with AGIS software

Thank you for your attention!

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