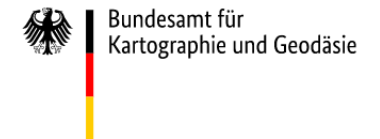




NAVISP-EL2-069 “SSRoverDAB+”

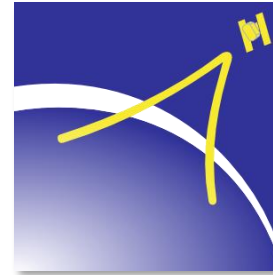
Precise GNSS PPP-RTK correction
data broadcasting via digital radio

Jürgen Alberding, 04.10.2022



Alberding GmbH

- **Alberding GmbH:**
 - SME founded in 1994 by Jürgen Alberding
 - Based in Wildau (near Berlin)
 - 19 employees (16 engineers)
- **Software** for server (cloud) and mobile applications
- Intelligent **Sensors** for precise positioning (mm - dm) applications and wireless data transfer
- Complete **System solutions** for multiple applications
- **Services** (distribution and monitoring of GNSS corrections)
- **Market segments:** Agriculture, Construction, Forestry, Inland Waterways, Geo-monitoring, GIS, Surveying, Transportation



System approach of Alberding GmbH

- Cloud solutions for multiple GNSS and location-based applications
- Telemetry and positioning sensors with Alberding data management software
- Software solutions for field applications (APP, machine positioning)
- Data capture for precise IoT applications



Telemetry and Positioning Sensors

- **Integration of precise GNSS positioning in telemetry sensors (since 2014)**

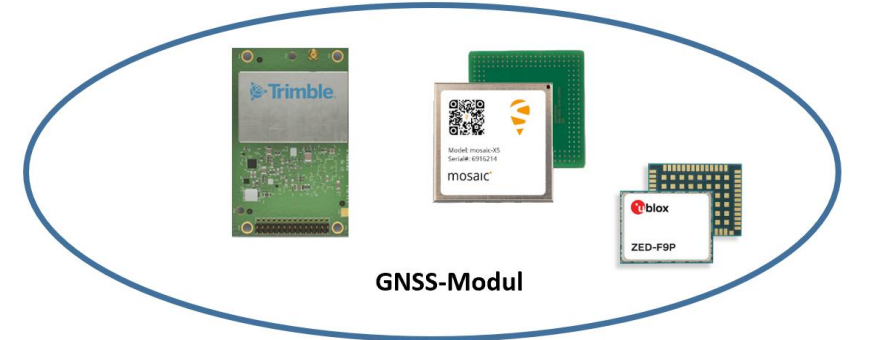
- Precise GNSS location via Multi-GNSS RTK Boards
- Additional sensors for positioning
- Other sensors (weather station, geotechnical sensors, ...)
- Machine data (Energy, CAN Bus,)

- **Requirements for the GNSS position**

- Everywhere in real-time without long convergence time
- Robust, reliable, redundant, ...
- Accuracy < 1dm => need for real-time GNSS corrections

- **Requirements for the GNSS corrections**

- Adequate for precise positioning
- Open data format
- Good coverage (100%) of the data link



Speicher



Prozessor



IMU

Real-time GNSS corrections and correction data distribution

- **EGNSS**

- EGNOS (0,6m – 2m) – open data format (RTCA) – geostationary satellite and Internet – Coverage Europe +
- Galileo HAS (0,2 – 0,4m) – open data format – Galileo satellites and Internet – Coverage global

- **Public GNSS service providers (SAPOS in Germany)**

- SAPOS HEPS service (0,02 – 0,05m) – open data format (RTCM 3.X) – Germany, 16 states – Internet
- **Future PPP-SSR service (0,02 – 0,05m) – data format ??? – coverage Germany (1 data stream) – Internet and DAB+**

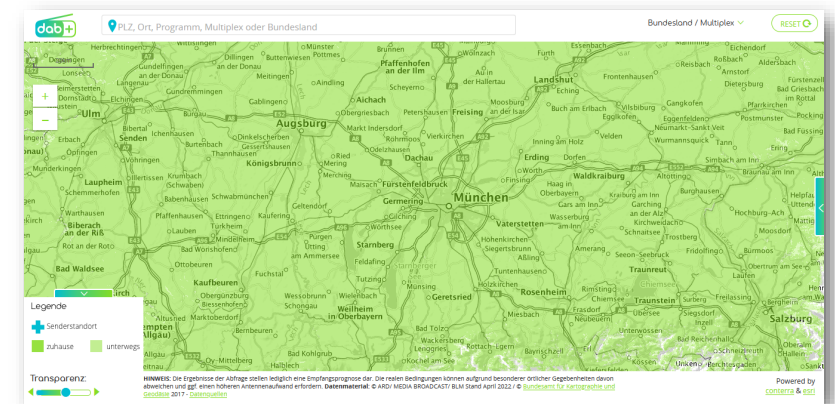
- **Private GNSS service providers**

- Trimble, Hexagon, others (0,02 – 0,05 cm) - geostationary satellite and Internet – proprietary data format – coverage global

Global operating companies are using their GNSS-service to secure their system solution sales

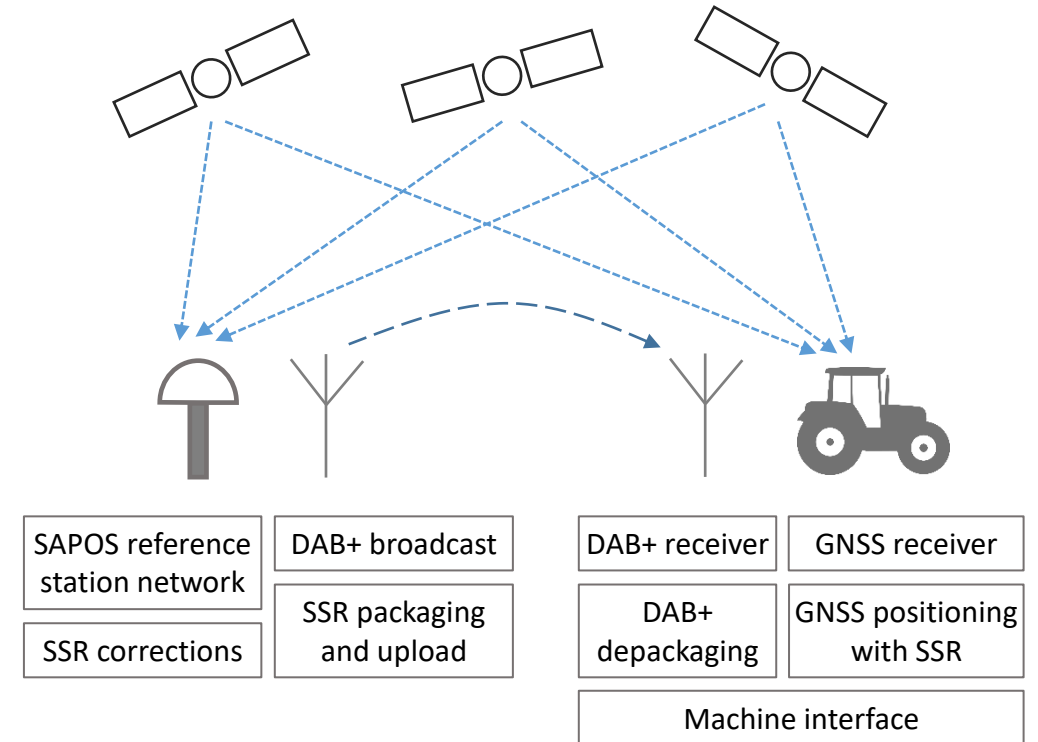
Challenges for using the SAPOS SSR service via DAB+

- **Data format for PPP-RTK corrections is not fully standardized**
 - No commercial GNSS RTK modules are available for PPP-RTK processing
 - Development of processing algorithms using PPP-RTK corrections
- **DAB+ is a new medium for broadcasting GNSS corrections**
 - Optimization of a correction data format (SSRZ) for the DAB+ broadcast
 - Realization of the data stream modulation
- **Integration of the developments in a commercial product**
 - Development of a DAB+ signal receiving unit
 - Integration of the processing and decoding algorithms
- **Adaptations of the product to customer needs**
 - Integration of a sensor fusion algorithm
 - Reading machine data



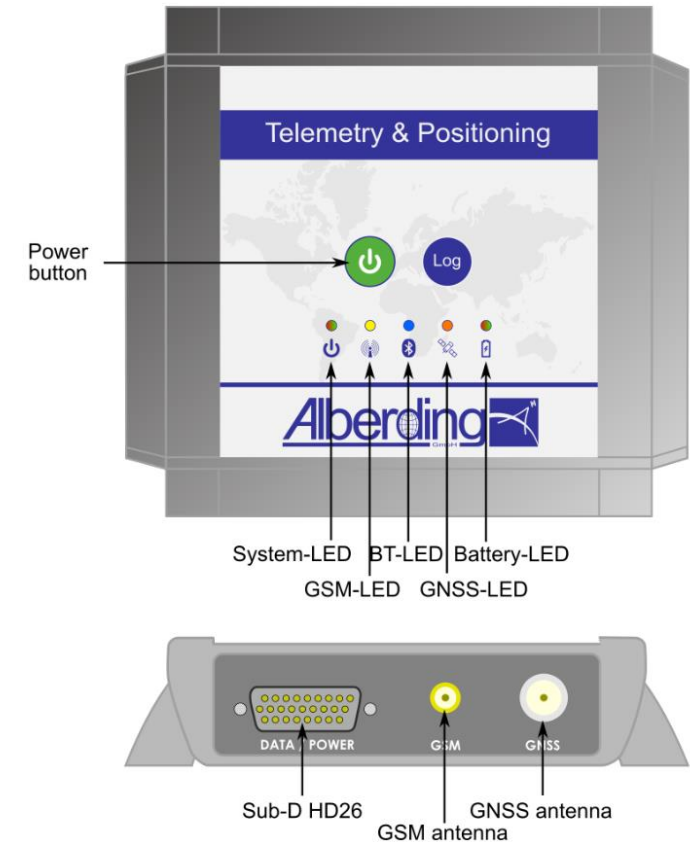
Project goals

- **Increase the availability** of high-accuracy GNSS corrections in rural regions using DAB+ transmission
- **Overcome** computational and bi-directional communication **limitations of network RTK**
- Compute and compare **different SSR-based GNSS position solutions**
 - COTS receiver internal RTK solution using SSR2OBS conversion
 - External PPP-RTK solution optimised for SSR
 - Robust E5AltBOC code-based solution using SSR corrections
- Demonstrate the complete solution in a **market-ready user product**

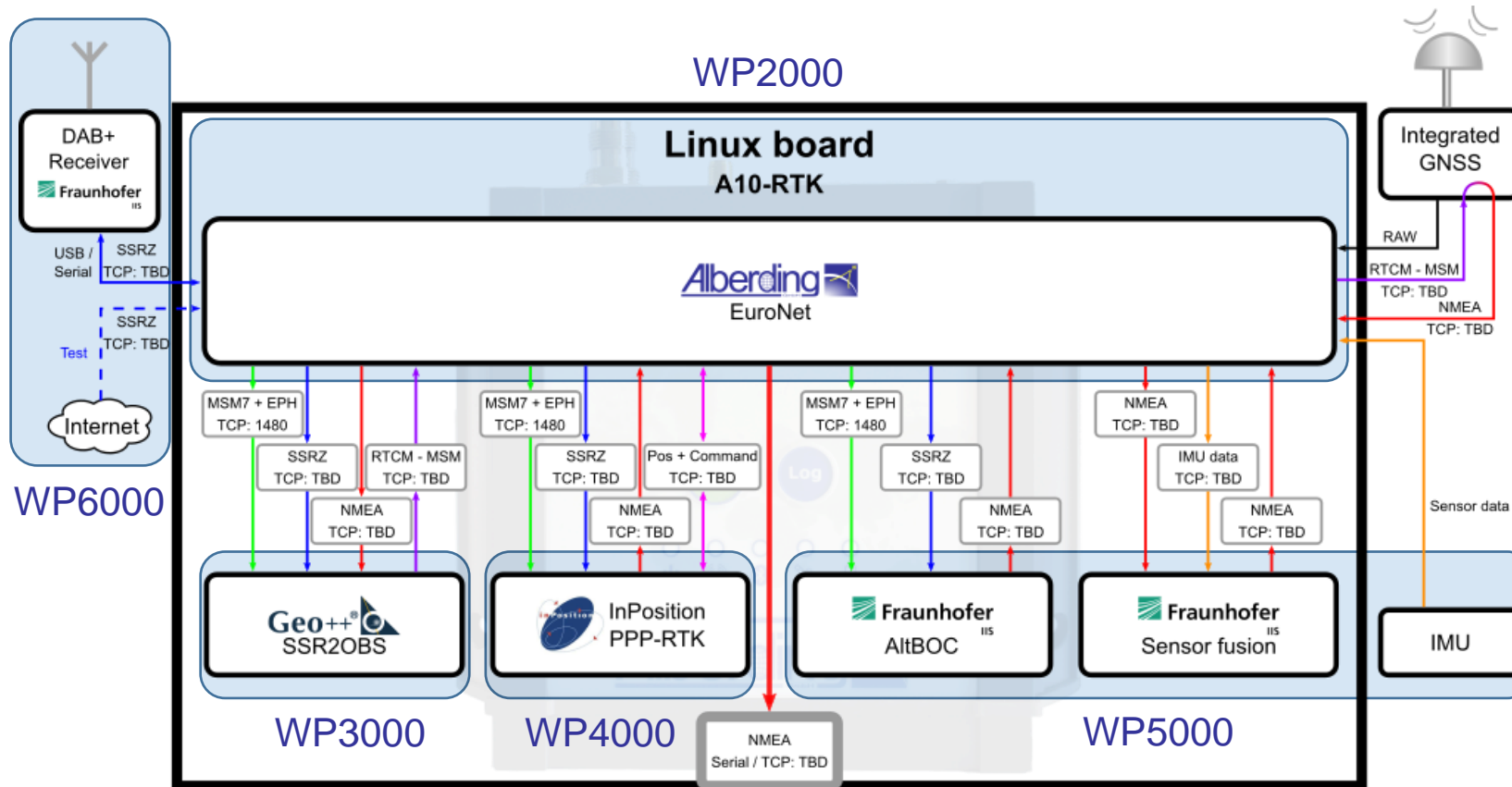


Sensors for precise GNSS applications

- Alberding A10-RTK – a versatile GNSS sensor
 - Integrated multi-frequency GNSS RTK-board
 - Supported suppliers: u-blox / Trimble / Septentrio / Others
 - Integrated 4G LTE modem
 - Integrated memory (SD-card)
 - Integrated Bluetooth + WiFi module
 - Integrated Cortex M4 processor
 - 26-pin connector with multiport adapter (Ethernet, RS232, power) or octopus cable (Ethernet, RS232, 1PPS output, Event in, USB, power)
 - External GNSS- and GSM-Antenna
- **Optional embedded PC with Linux OS and EuroNet software**
 - Data conversion (e.g. signal decoding, SSR2OBS)
 - Customer algorithms (RTK, sensor fusion, monitoring, etc.)

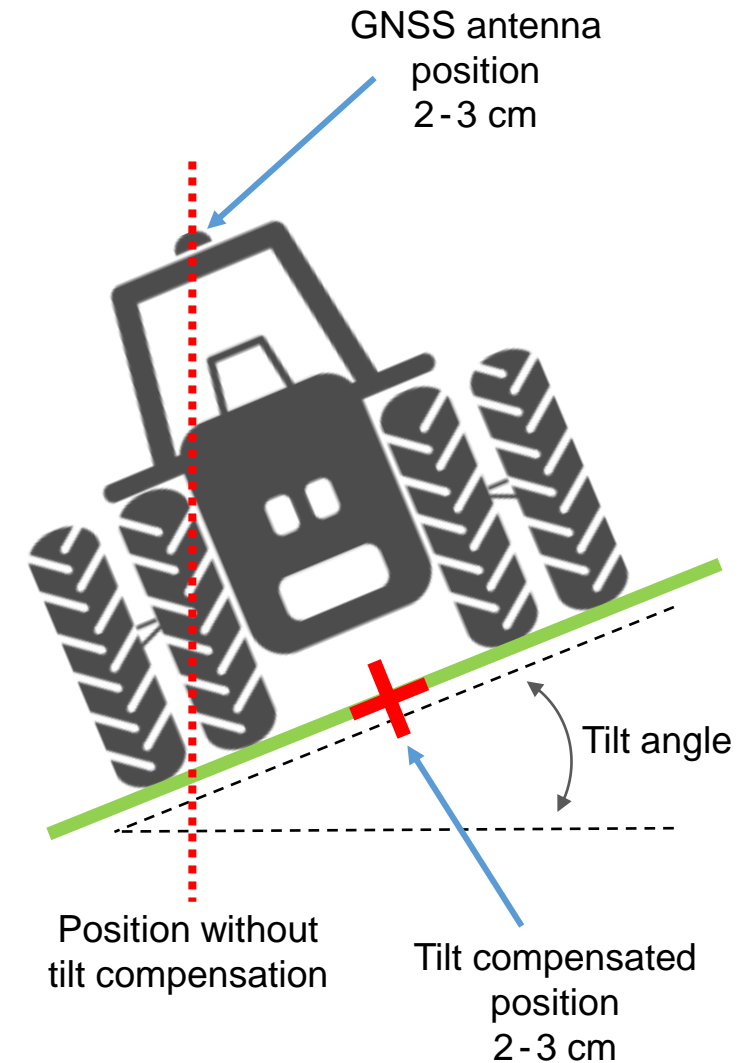


SSRoverDAB+ extension of A10-RTK



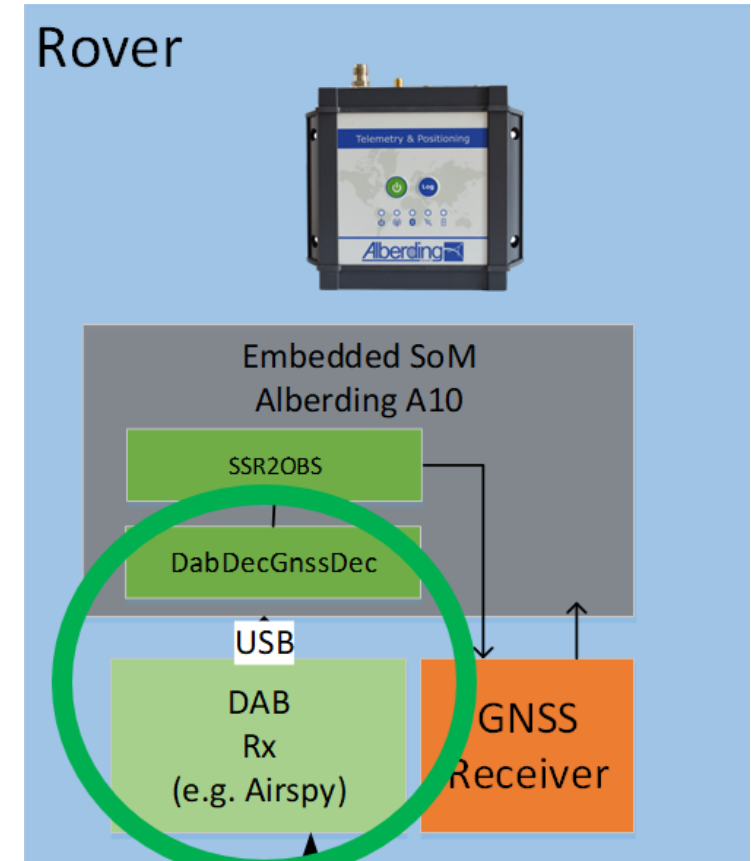
Receiver integration

- Integration of external software into the Alberding A10-RTK receiver
 - Integration of the SSR corrections via DAB+ (Fraunhofer IIS)
 - Integration and optimisation of the SSR2OBS data conversion module (Geo++)
 - Integration of the PPP-RTK positioning algorithms (inPosition)
 - Integration of the E5AltBOC code-based positioning algorithms (Fraunhofer IIS)
 - Integration of the INS sensor and the fusion algorithms (Fraunhofer IIS)
- Integration of the A10-RTK receiver into an agricultural machine
- Setup of the SSRoverDAB+ demonstrator
- Agricultural field tests (BayWa, universities, other interested parties)



Outcome out of the project

- Increase of the functionality and attractiveness of the Alberding A10-RTK telemetry and positioning sensor in the agriculture and waterway markets by:
 - Using open PPP-RTK corrections from the SAPOS network
 - High quality correction data (dense network)
 - Single data stream for Germany
 - Open data free of charge
 - Using existing DAB+ transmission infrastructure
 - Increasing the coverage of the corrections
 - No running costs for the data link
 - Using lower cost GNSS sensors with open interfaces
 - Development of own software and system solutions



Future developments

- Integration of the solution in other Alberding telemetry and positioning sensors



GEO-MICHEL



A08-Bake



Intelligent buoy



Geo-monitoring

Impact of the project on Alberding GmbH

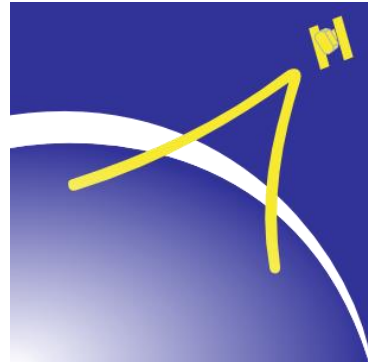
- **Chance to stay in the precise GNSS market because of a competitiveness in pricing and performance**
- **Growth of the company with the growing market of precise GNSS applications (IoT, automation, digitalisation, robotic)**
- **Recognition and reputation of Alberding GmbH will increase in the GNSS market by leading successful research and innovation projects**
- **International companies will recognize Alberding as a potential partner:**
 - Research projects
 - System integrators
 - Distributors



Working with ESA

- **First impression: Too much paper work**
 - Proposal very time consuming
 - Contract (negotiation, paper work, ...)
 - Documentation (Minutes of the meeting, reports, ...)
- **Advantages**
 - International view on local markets
 - Experiences in project management
 - Strength, weaknesses and project focus
 - European visibility of the project
 - International approach for the products (markets)
 - Help to address the right markets





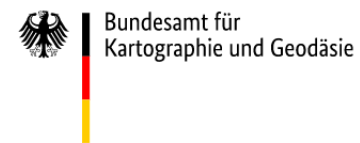
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Project information

- Funded in the frame of the European Space Agency's Navigation, Innovation and Support Programme (ESA NAVISP Element 2)
- **NAVISP-EL2-069 "SSRoverDAB+"**
- Total budget: EUR 645,263.-
- ESA funding: EUR 558,497.-
- Project duration: 12 months (May 2022 – April 2023)
- Project partners: Alberding GmbH (lead), Fraunhofer IIS, Geo++ GmbH, inPosition gmbh
- Associated partners: Landesamt für Digitalisierung, Breitband und Vermessung Bayern (LDBV), Bundesamt für Kartographie und Geodäsie (BKG), BayWa AG



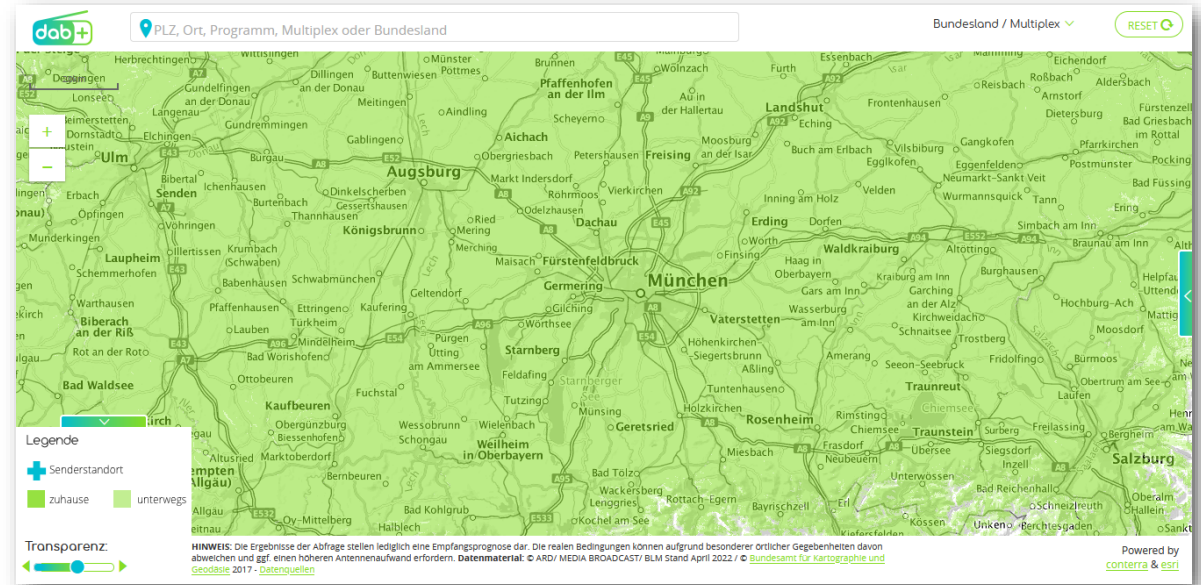
Mobile internet vs. DAB+ coverage areas

- Example area: southern Bavaria
- 4G/LTE coverage with white spots



https://t-map.telekom.de/tmap2/coverage_checker/

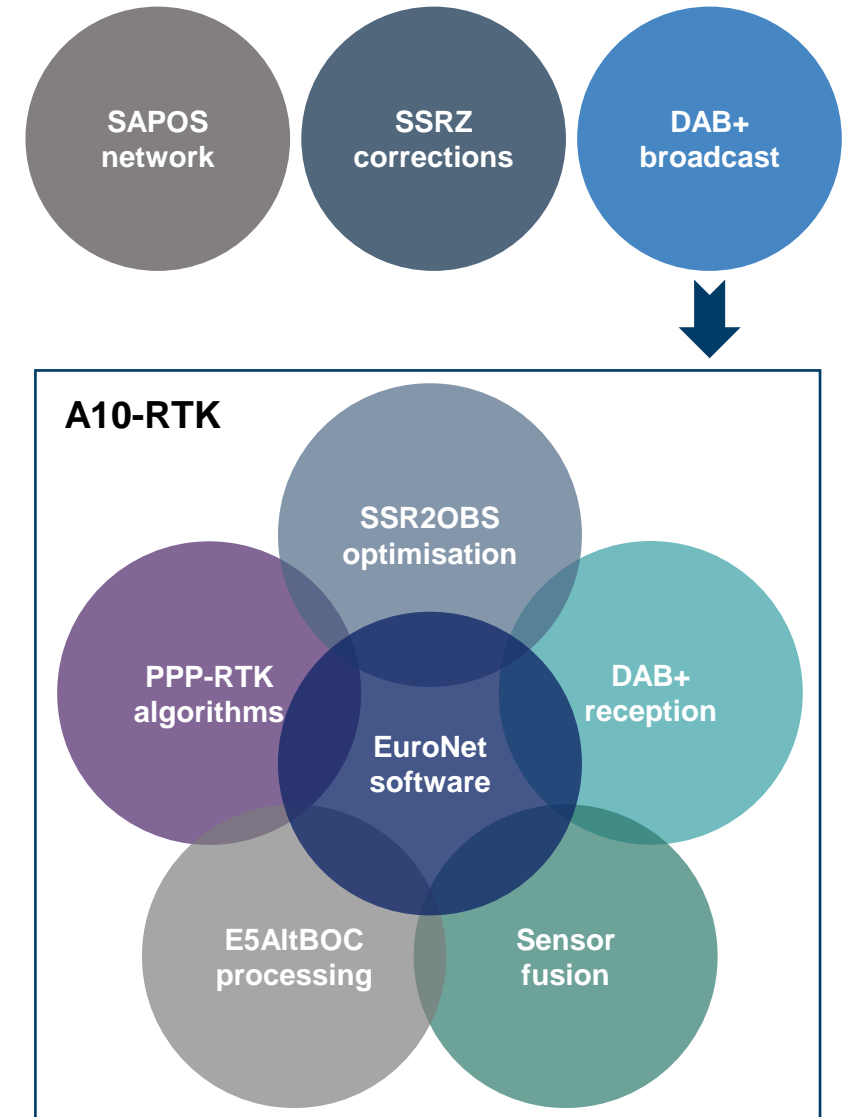
- DAB+ coverage



<https://www.dabplus.de/empfang/>

Project tasks

- Generation of a broadcast-capable **SSR (PPP-RTK) correction** data stream with optimised bandwidth
- Encoding and decoding of **DAB+ transmission** data
- Development and adaptation of **algorithms for precise real-time positioning**
 - SSR2OBS optimisation
 - PPP-RTK rover positioning algorithms
 - Galileo E5AltBOC processing with SSR correction data
- Implementation of software modules on the embedded computer of the Alberding **A10-RTK** GNSS sensor
- Conducting agricultural and automotive **field tests**



Roles of project partners

Alberding GmbH (DE)



- Project management
- Product provider
- Machine interface
- Field tests

Geo++ GmbH (DE)

- SSR correction generation
- SSR2OBS processing



LDBV / AdV (DE)*

- Reference network provider
- Correction service provider



Fraunhofer IIS (DE)

- Galileo E5AltBOC position solution
- DAB+ encapsulation and decoding
- Sensor fusion



inPosition gmbh (CH)

- Receiver independent PPP-RTK solution



Bundesamt für Kartographie und Geodäsie

BKG (DE)*

- DAB+ data channel provider (Bundesmux)



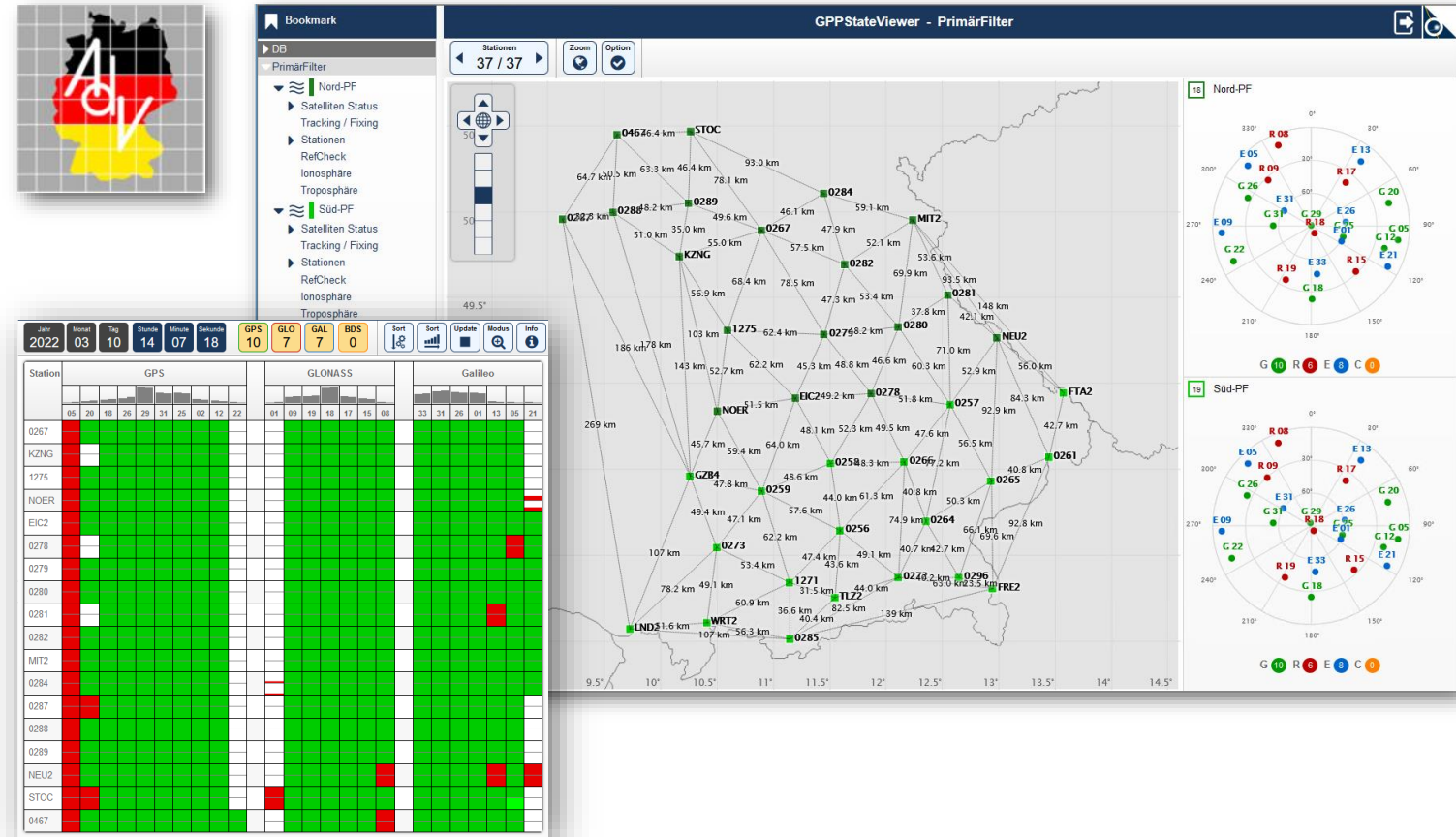
BayWa AG (DE)*

- Support of agricultural field tests



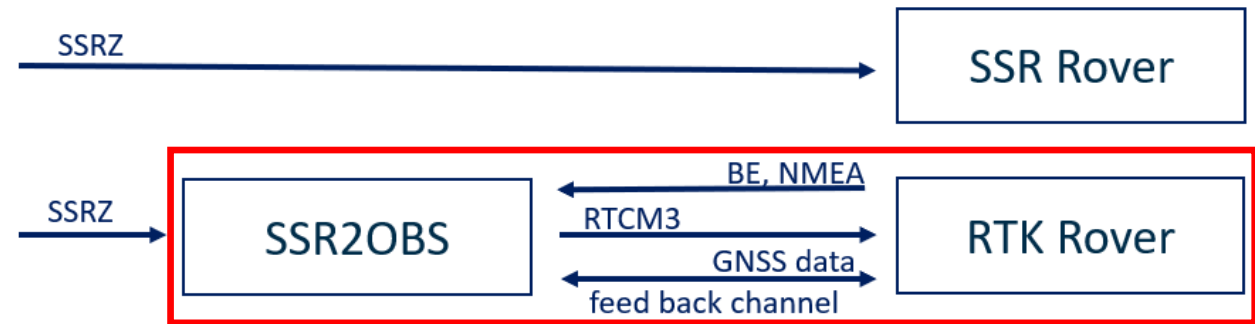
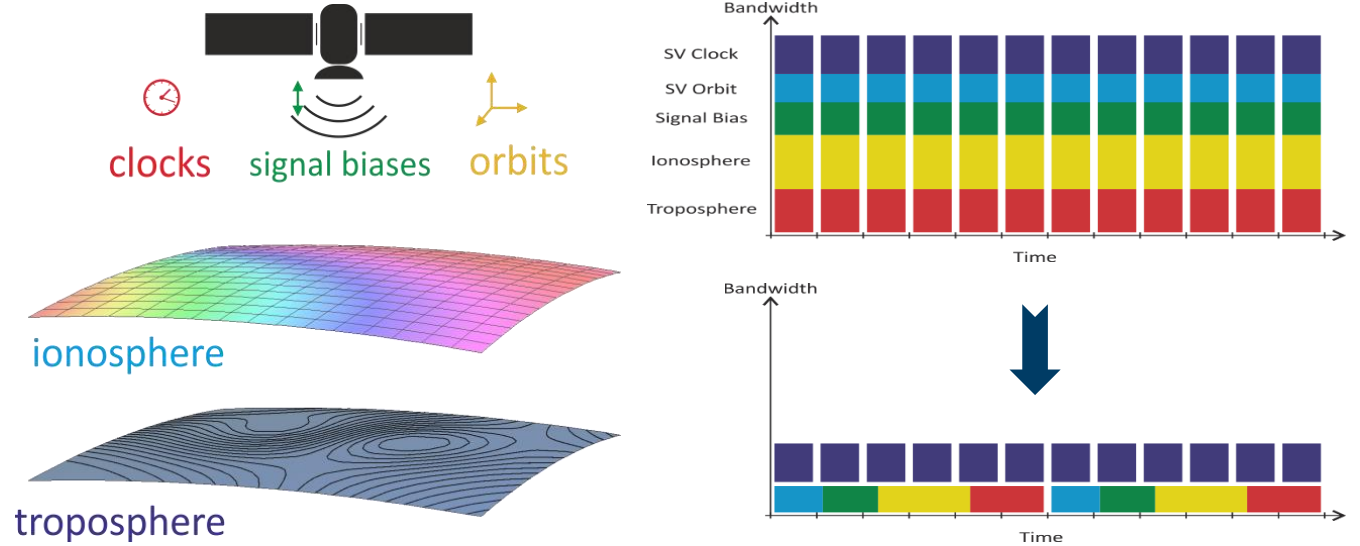
GNSS reference station network

- SAPOS reference station GNSS data provided by LDBV (Bavaria)
- Network serving as AdV PPP-RTK testbed in Germany
- SSR networking of Bavarian reference stations within two networks North and South
- SSR service provided using Geo++ SSRZ format via Ntrip and DAB+ (Bayerischer Rundfunk)



SSR correction preparation

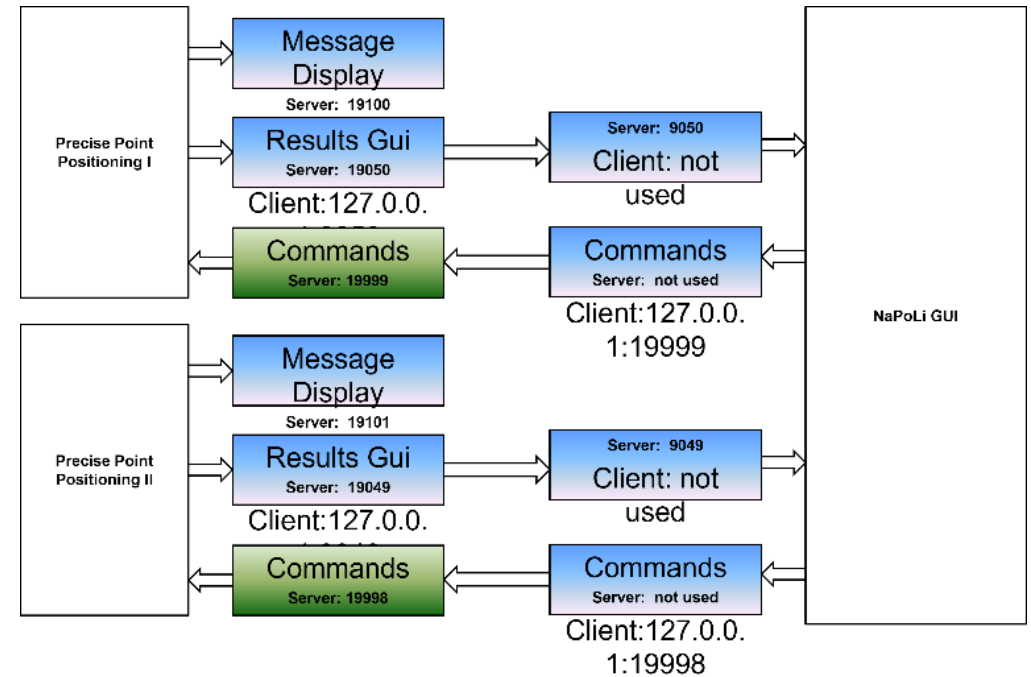
- Geo++ SSRZ format uses individual characteristics of GNSS error components to reduce bandwidth
- SSRZ data format to be optimised for DAB+ data broadcasting
- SSRZ data can be used directly by an SSR rover or after SSR2OBS conversion by a COTS RTK rover
- SSR2OBS to have a new feedback channel for enhanced SSR corrections



A10-RTK

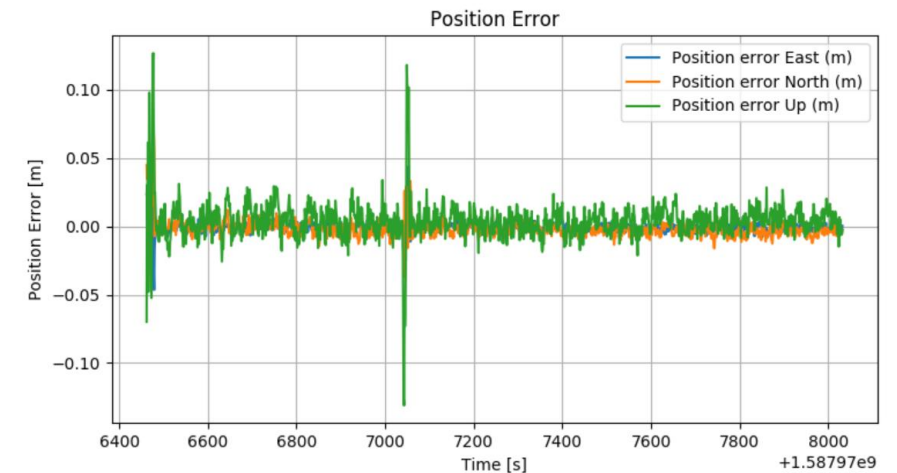
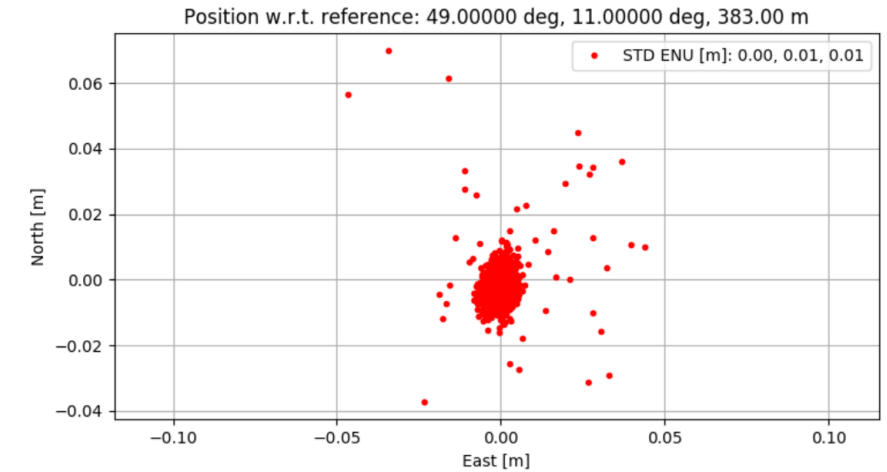
PPP-RTK position solution

- Cross-compilation of inPosition algorithms for ARM Linux on A10-RTK
- Implementation of SSRZ data format and contents
- Optimisation for delayed and sparse transmission via DAB+ channel
- Interface to Alberding EuroNet software on the A10-RTK
- Optimisation for u-blox or alternative receiver observations
- Simulation and testing



Galileo E5AltBOC position solution

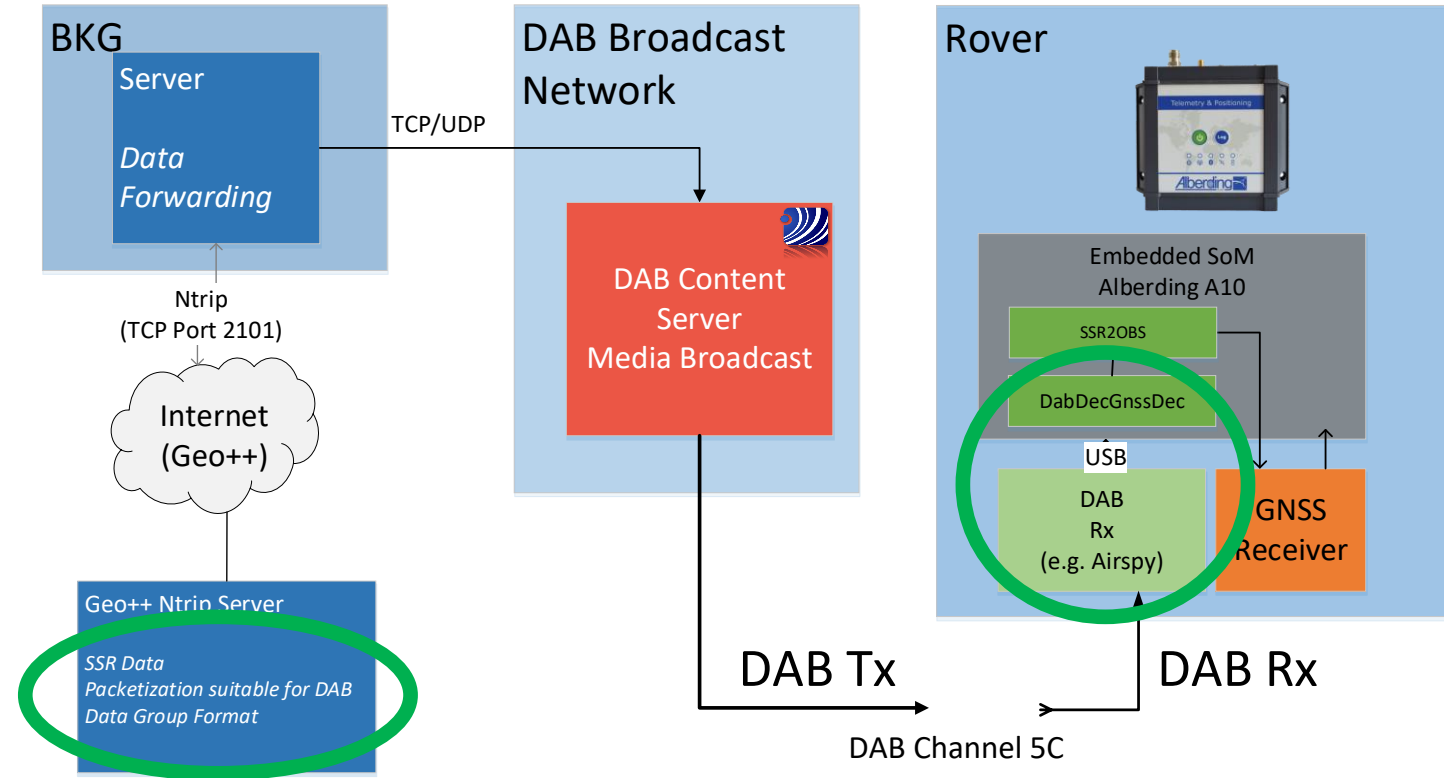
- Cross-compilation of Fraunhofer algorithms for ARM Linux on A10-RTK
- Interface to Alberding EuroNet software on the A10-RTK
- Robust, decimetre-accurate position solution using the Galileo E5AltBOC signal
- Alternative position calculations
 - Use SSR2OBS to correct the E5AltBOC raw data of A10-RTK
 - Use SSRZ corrections directly with A10-RTK E5AltBOC code measurements
 - Use SSRZ corrections directly in the Fraunhofer IIS GOOSE platform
- Additional sensor fusion (loosely coupled)



E5AltBOC only position solution
(simulation without atmosphere)

DAB+ broadcasting

- Transmission: SSRZ transfer over DAB+
 - Interface definition and implementation
 - SSRZ data optimisation for DAB+ transmission (e.g. handling of data losses)
- Reception: DAB+ receiver module
 - Hardware interface of DAB+ tuner to A10-RTK
 - Software interface of DAB+ receiving software to the EuroNet software on the A10-RTK



GNSS target markets

Target market of the project: Agriculture

Other market segments could take profit from the project:

- 1) Forestry
- 2) Construction machines
- 3) Automotive (autonomous driving, tolling)
- 4) Surveying and GIS
- 5) Inland waterways
- 6) Railway applications
- 7) Precise IoT applications (e.g. geomonitoring)
- 8)

GNSS correction delivery via DAB+ could provide a value in terms of **service area extension** and **price** to a wide range of GNSS users in different market segments.