MOLDPOS Scientific RaD-Project (BMBF)

- Geodetic Infrastructure for MOLDPOS GNSS-Positioning and GNSS-Technologies –

- www.moldpos.eu -

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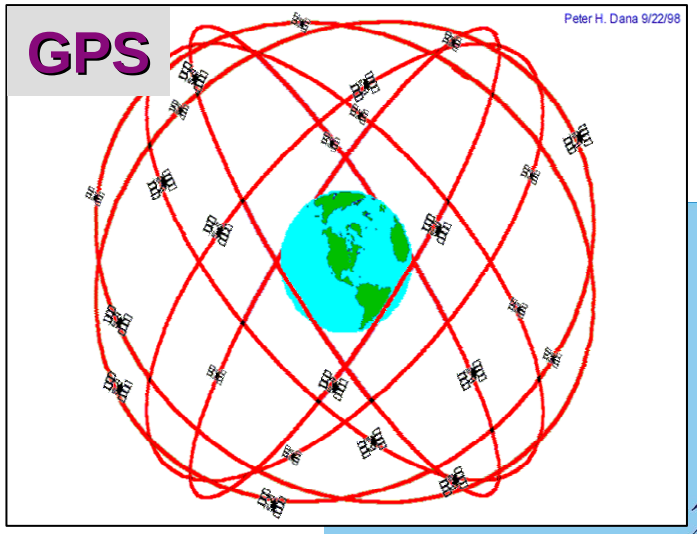
Moltkestrasse 30, D-76133 Karlsruhe

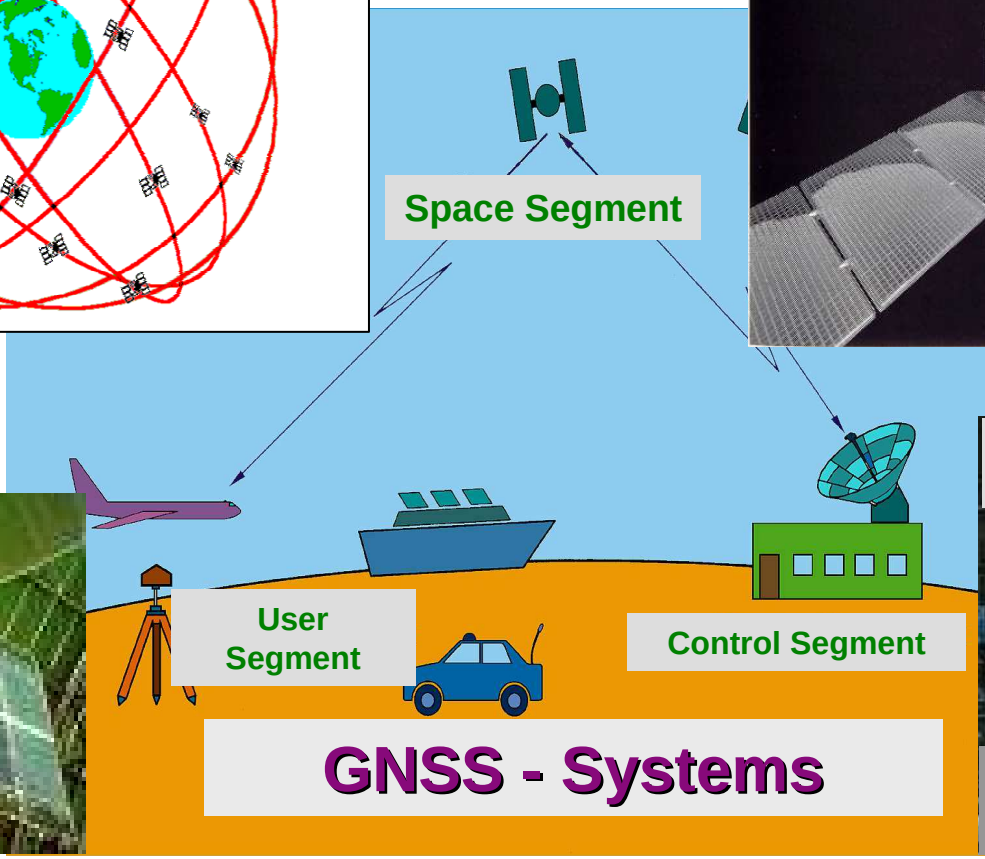
RaD-URL
www.goca.info , www.dfhbf.de, www.monika.ag
www.geozilla.de, www.galileo-bw.de

GNSS for Global Positioning in ITRF/ECEF Frames



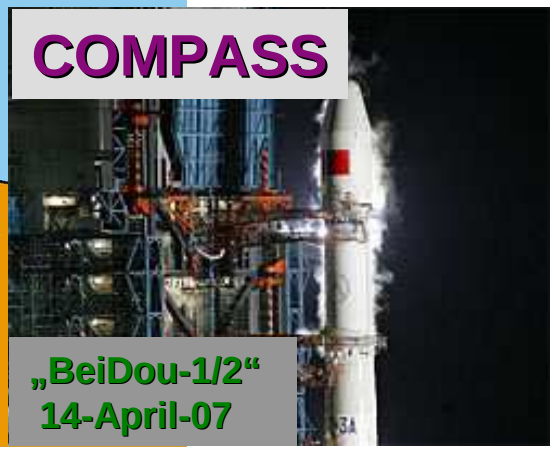
< 50 (2010)

105! (2013)



GLONASS

COMPASS



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GNSS-Positioning-Services in Eastern Europe

www.euref.eu

GNSS-Networks in EURASIA: SAPOS®/Axio-Net/VRSNow® , SWIPOS®/SwissSat® … SwePos®, CzePos® ,LatPos®, CroPOS®, HePos® , … Hungary, Slowenia, Romania, Moldavia,

MOLDPOS Scientific Project = Geodetic Infrastructure for GNSS-Service MOLPDOS

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GNSS-Services and RTCM-based Positioning

Basic GNSS-Data collected at the GNSS-Reference-Stations at a Time t-Δt

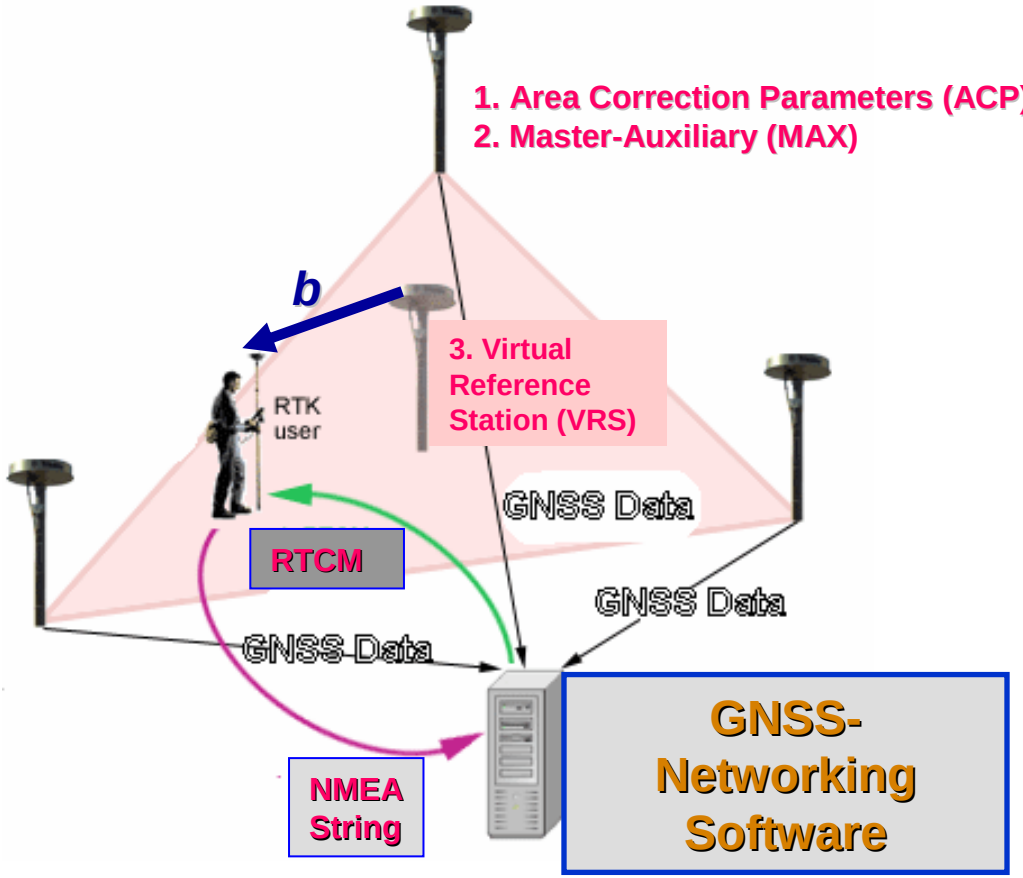
$$\nabla\rho(t-\Delta t)^{Sat}_{Ref} = \rho[(x,y,z)_{REF};(x,y,z)_{SAT,\Delta t}]_{true,Ref} - \rho(t-\Delta t)_{Observed,Ref}$$

$$\nabla\lambda_R(t-\Delta t)^{Sat}_{Ref} = \lambda_R[(x,y,z)_{REF};(x,y,z)_{SAT,\Delta t}]_{true,Ref} - \lambda_R(t-\Delta t)_{Observed,Ref}$$

RTCM 3.1
Observations-
Corrections

$$\lambda_R(t)^{Sat}_{Rov,corrected} = \lambda_R(t)^{Sat}_{Rov,Observed} - \nabla\lambda_R(t-\Delta t)^{Sat}_{Ref}$$

→ $(B,L,h)_{GNSS\text{-}Datum}$
1 - 2 cm



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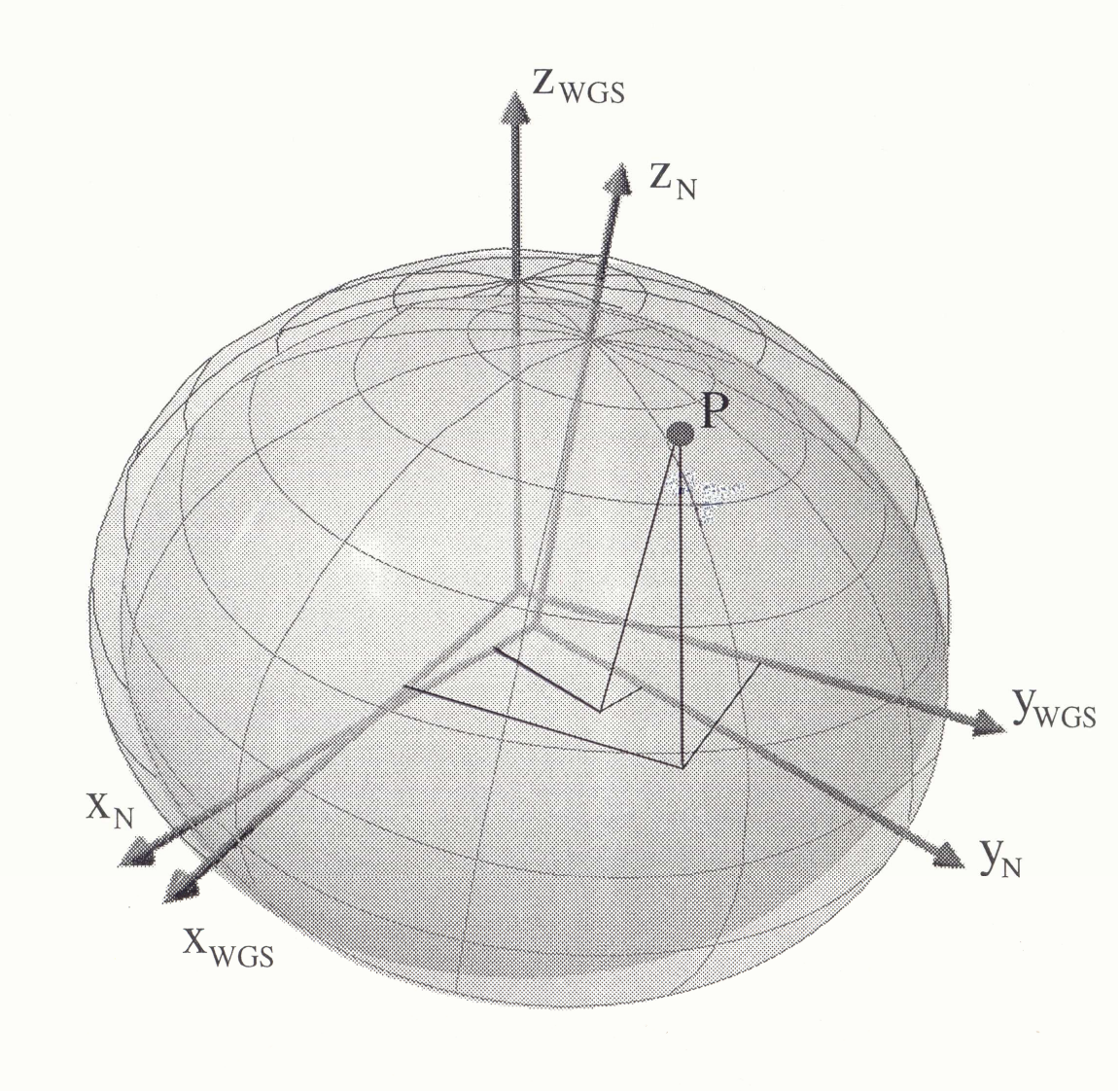
Geodetic Infrastructures for GNSS-Services

1.) Present Datum - Transformation Problem



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Solution of the Transformation Problem

3D Similarity Transformation Related to (B,L,h)

$$\left(\begin{bmatrix} B \\ L \\ h \end{bmatrix}_2 - \begin{bmatrix} \Delta B_{(a,b)_1,(a,b)_2} \\ \Delta L_{(a,b)_1,(a,b)_2} \\ \Delta h_{(a,b)_1,(a,b)_2} \end{bmatrix} - \begin{bmatrix} B \\ L \\ h \end{bmatrix}_1\right)_i + \begin{bmatrix} v_B \\ v_L \\ v_h \end{bmatrix}_i = [\text{Moldenski}]_{(B,L,h)_1,i} \cdot \begin{bmatrix} \varepsilon_x \\ \varepsilon_y \\ \varepsilon_z \\ \Delta s \\ t_x \\ t_y \\ t_z \end{bmatrix}$$

Advantage: 1D or 2D or 3D identical points !!!

$$\begin{bmatrix} -\sin(L)\cdot\frac{a\cdot W+h}{M+h} & \cos(L)\cdot\frac{a\cdot W+h}{M+h} & 0 & \frac{-\sin(B)\cdot\cos(B)\cdot N\cdot e^2}{M+h} & \frac{-\sin(B)\cdot\cos(L)}{M+h} & \frac{-\sin(B)\cdot\sin(L)}{M+h} & \frac{\cos(B)}{M+h} \\ \frac{\sin(B)\cdot\cos(L)\cdot(N\cdot(1-e^2)+h)}{(N+h)\cdot\cos(B)} & \frac{\sin(B)\cdot\sin(L)\cdot(N\cdot(1-e^2)+h)}{(N+h)\cdot\cos(B)} & -1 & 0 & \frac{-\sin(L)}{(N+h)\cdot\cos(B)} & \frac{\cos(L)}{(N+h)\cdot\cos(B)} & 0 \\ -N\cdot e^2\cdot\sin(B)\cdot\cos(B)\cdot\sin(L) & N\cdot e^2\cdot\sin(B)\cdot\cos(B)\cdot\cos(L) & 0 & h+a\cdot W & \cos(B)\cdot\cos(L) & \cos(B)\cdot\sin(L) & \sin(B) \end{bmatrix}$$

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Germany West

Strict 3D-Trafo in (B,L, (h))

Residuals Germany

Only 1 set of 7 parameters

(= Without „Patching“)

Mean Residual:

1.49 m

Max. Residual:

2.43 m

Longwaved Systematic Errors „Weak Shapes“

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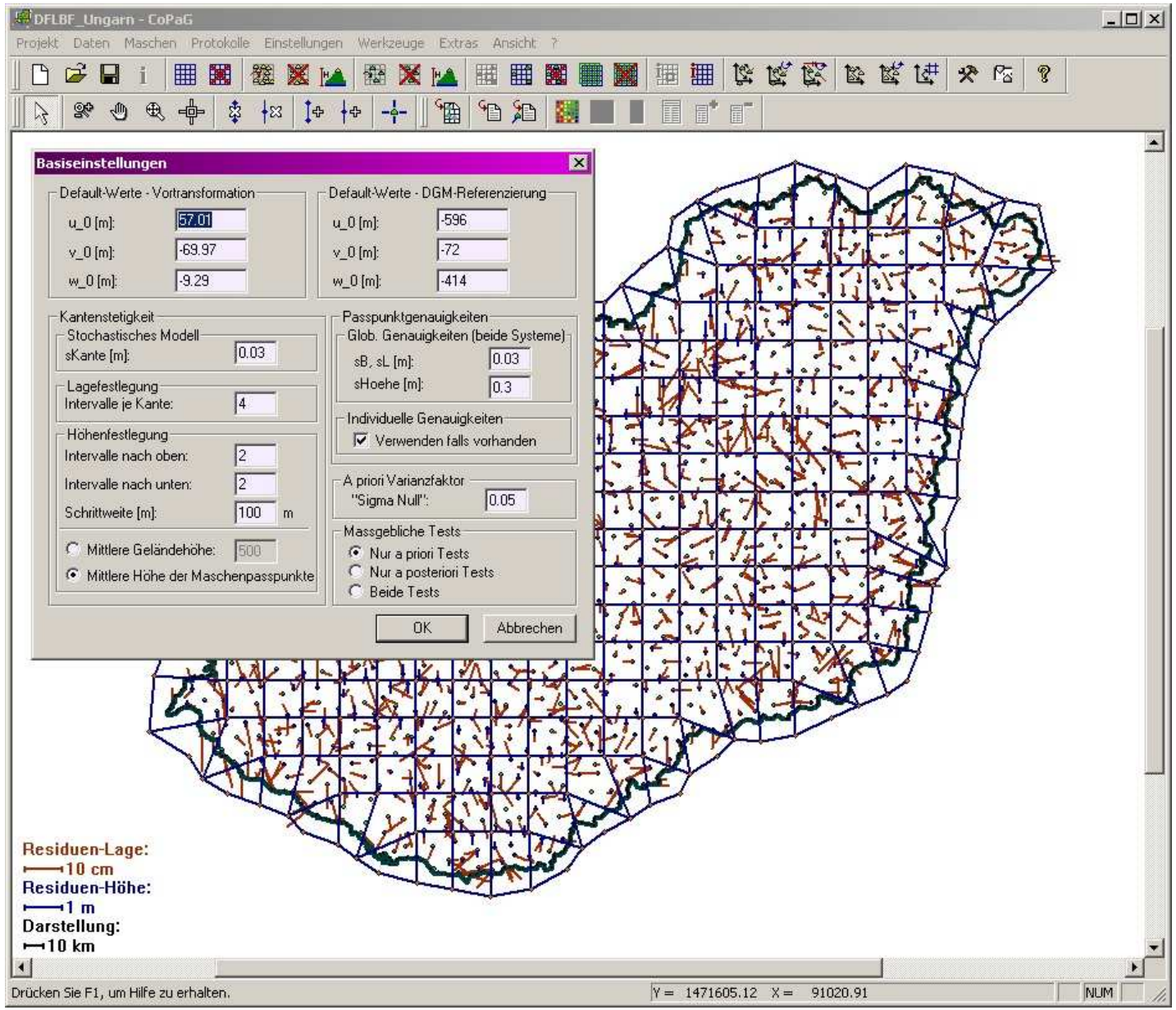
DFLBF_COPAG_DB – Hungaria



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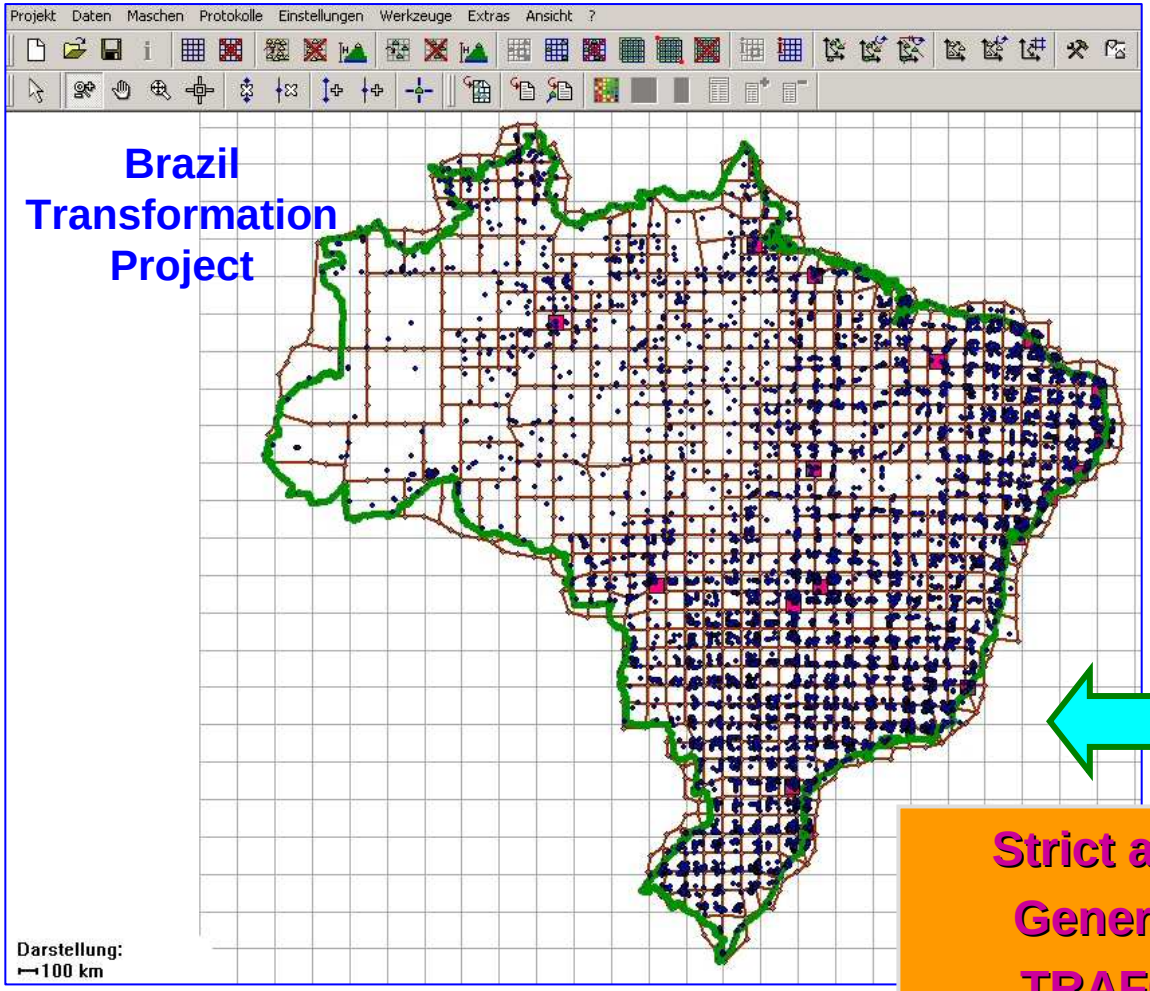
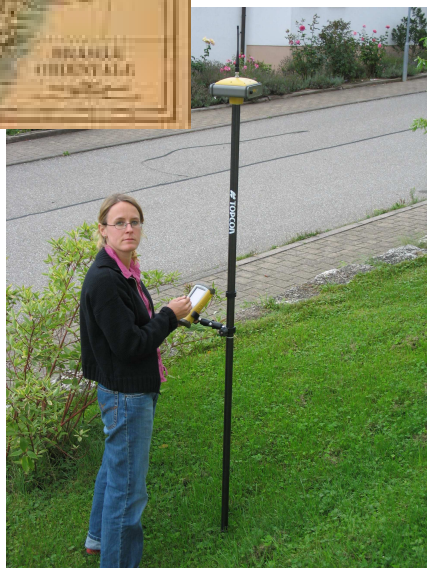
Transformation Problems and Reference Transformations
1.) Horizontal Datum Transition from $(B,L)_{GNSS,ITRF}$ to Classical Datum $(B,L)_{Classical}$





Strict and General TRAFO

ITRF / SIRGAS - Datum

Old Classical Systems

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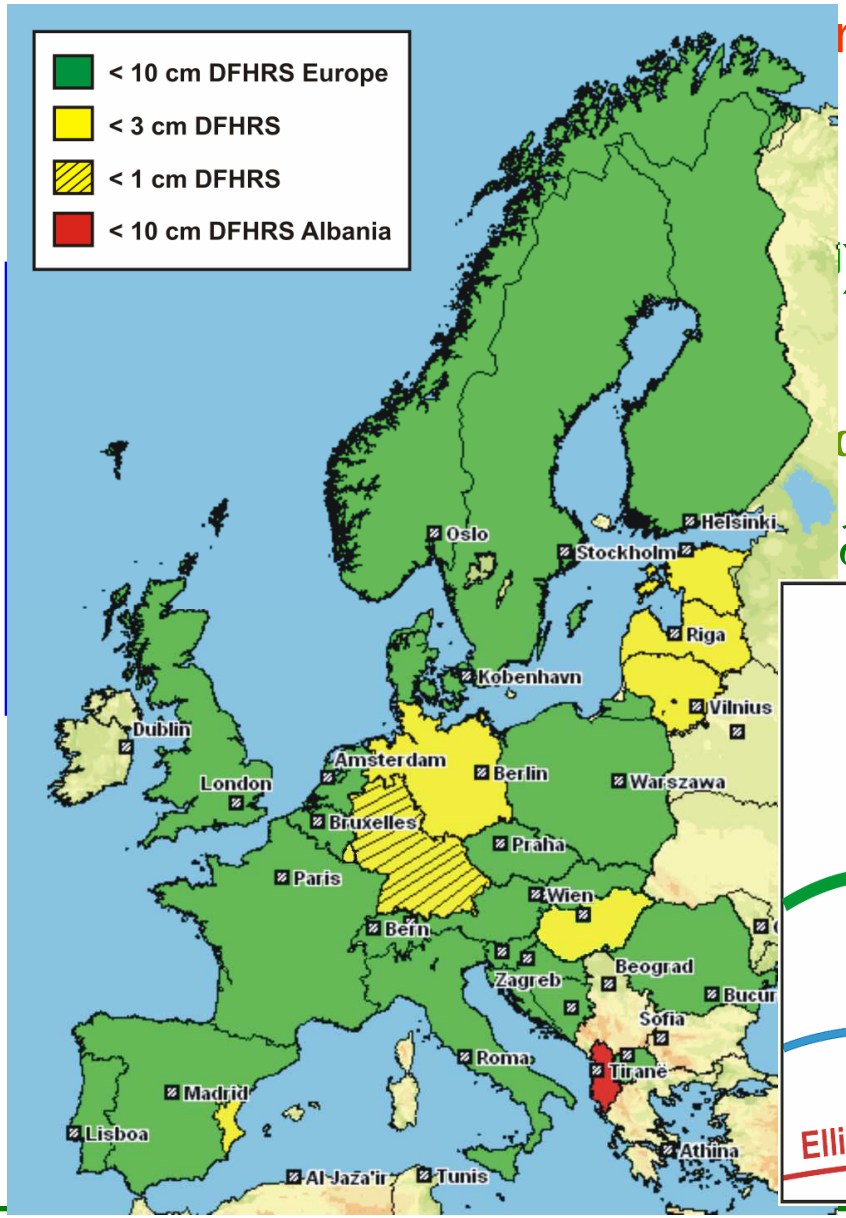
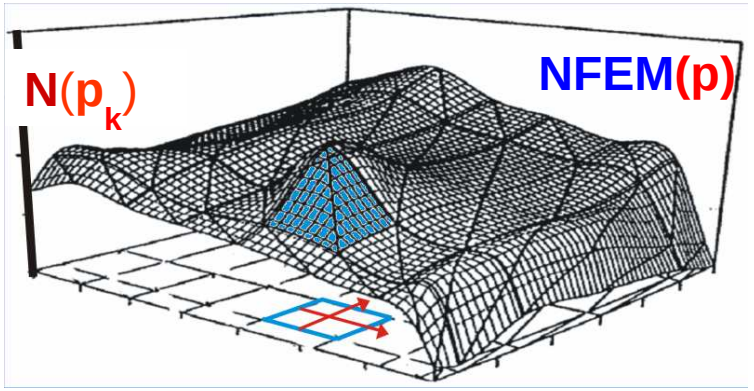
2. Height Problem / HRS Transition - Karlsruhe Reference Transformation



m

$d_{\xi,\eta})^{j}$

$\partial\,\eta(d_{\xi,\eta})^{j}$



DFHBF DB

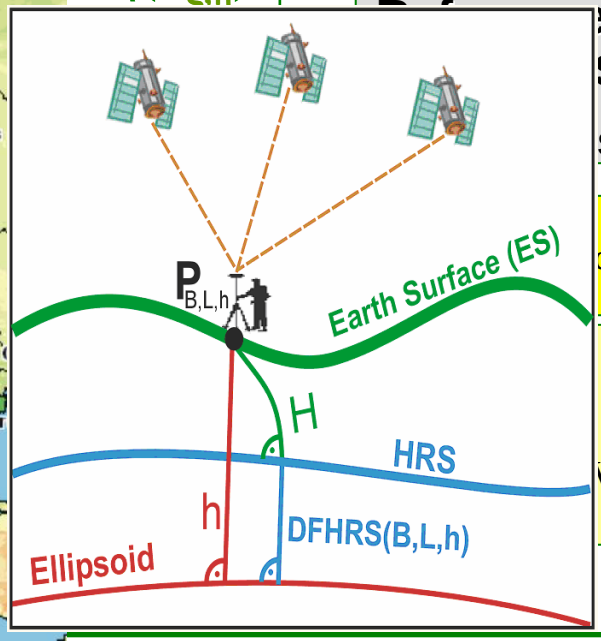
-Transformation

S Target CRS

S => N

$\cos\theta') + dg(\mathbf{d})$

$Vref) + \partial N(\mathbf{d}^{j})$



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Extension of the DFHRS-Concept to gravity observations

$$\mathbf{h_{GNSS}} + v = H + \mathbf{f}^T \cdot \mathbf{p} - h_{GPS} \cdot \Delta \mathbf{m}$$

$$\mathbf{H} + v = H$$

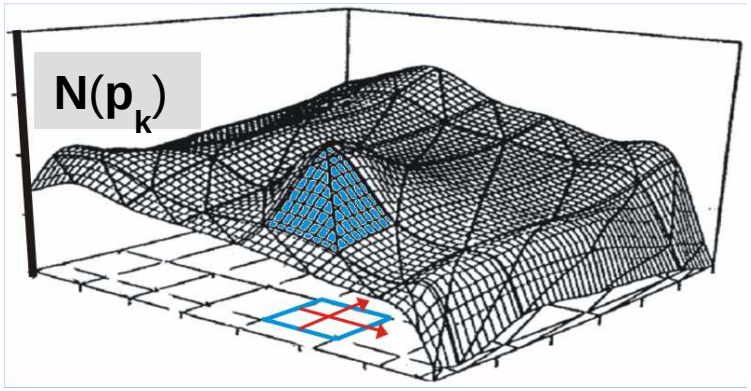
$$\mathbf{N_G}'^{j} + v^{j} = \mathbf{f}^T \cdot \mathbf{p} + \partial N_G(\mathbf{d}^{j})$$

$$\xi^{j} + v = -\mathbf{f}_B^{\,T} / M(B) \cdot \mathbf{p} + \partial \xi(\mathbf{d}_{\xi,\eta})^{j}$$

$$\eta^{j} + v = -\mathbf{f}_L^{\,T} / (N(B) \cdot \cos(B)) \cdot \mathbf{p} + \partial \eta(\mathbf{d}_{\xi,\eta})^{j}$$

$$\frac{a}{4\pi\gamma(B)} \iint_{\sigma} \Delta \mathbf{g} \cdot S(\psi) d\sigma + v = \mathbf{NFEM(p)} = \mathbf{f}^T \cdot \mathbf{p}$$

NFEM(p)



$$g^{LGV}_{grav\,r} + v = \sum_{k=0}^{\infty} \left(\frac{a}{r}\right)^{n(k)+1} \frac{(n(k)+1)}{r} \sum_{m=0}^{k} (\bar{C}'_{n(k)),m} \cdot \cos m\lambda' + \bar{S}'_{n(k),m} \cdot \sin m\lambda') \cdot P_{n(k),m}(\cos\theta') + dg(\mathbf{d})$$

$$N^{j}_{GPM} + v = N(\bar{C}_{n(k),m}, \bar{S}_{n(k),m}) + \partial N(\mathbf{d}^{j})$$

$$= \frac{1}{\gamma_Q} \left(\sum_{k=0}^{\infty} \left(\frac{a}{r}\right)^{n(k)+1} \sum_{m=0}^{k} (\bar{C}'_{n(k),m} \cdot \cos m\lambda' + \bar{S}'_{n(k),m} \cdot \sin m\lambda') \cdot P_{n(k),m}(\cos\theta') - Vref \right) + \partial N(\mathbf{d}^{j})$$

$$0 + v_{\Delta N} = N(\bar{C}'_{n(k),m}, \bar{S}'_{n(k),m}) - (\mathbf{f}^T \cdot \mathbf{p} + \Delta m \cdot h)$$

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RTCM 3.1

RTCM 3.1 Observations Corrections
&
„7 RTCM Transformation Messages“

- Transformation-Parameters (1021,1022)
- Residual-Grids and/or Geoid-Representations (1023,1024)
- Projection-Information (1025,1026,1027)

sent by **GNSS-Positioning-Service**
to
GNSS-Positioning-User

NMEA-based request to RTCM-Transformation Messages Server)

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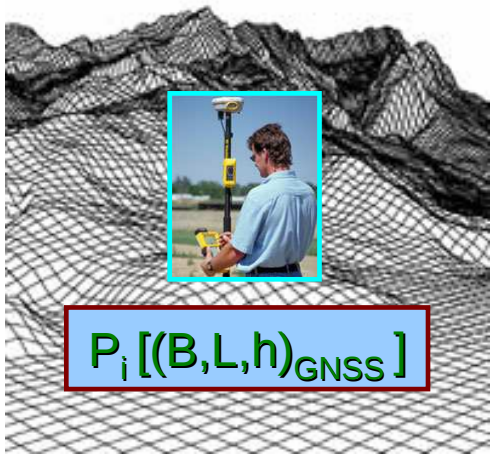
Gridding of Reference Transformations

Source CRS - Grid



Reference

Transformations

Target CRS - Grid

$P_i\,[(B,L)_{Class}]$

$P_i\,[(B,L,H)_{Class}]$

$P_i\,[N]$ $P_i\,[H=h_{GNSS} - N]$

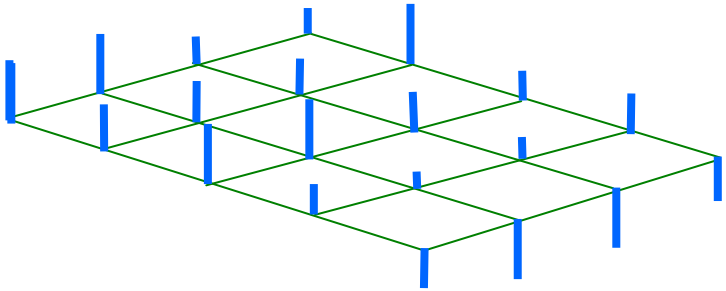
Virtual Fitting Points P_i — **Gridding** — **Virtual Fitting Points P_i**

1.] **7 Para meter Trafo**

$$\begin{bmatrix} x_T \\ y_T \\ z_T \end{bmatrix}_{Target,i} + \begin{bmatrix} r_x \\ r_y \\ r_z \end{bmatrix}_i = s \cdot \mathbf{R} \cdot \begin{bmatrix} x \\ y \\ z \end{bmatrix}_{Source/GNSS,i} + \begin{bmatrix} t_x \\ t_x \\ t_z \end{bmatrix}$$

7 Parameters
3 Residual Grid

2.] **Geoid/HRS Grid**



Grid of N_i

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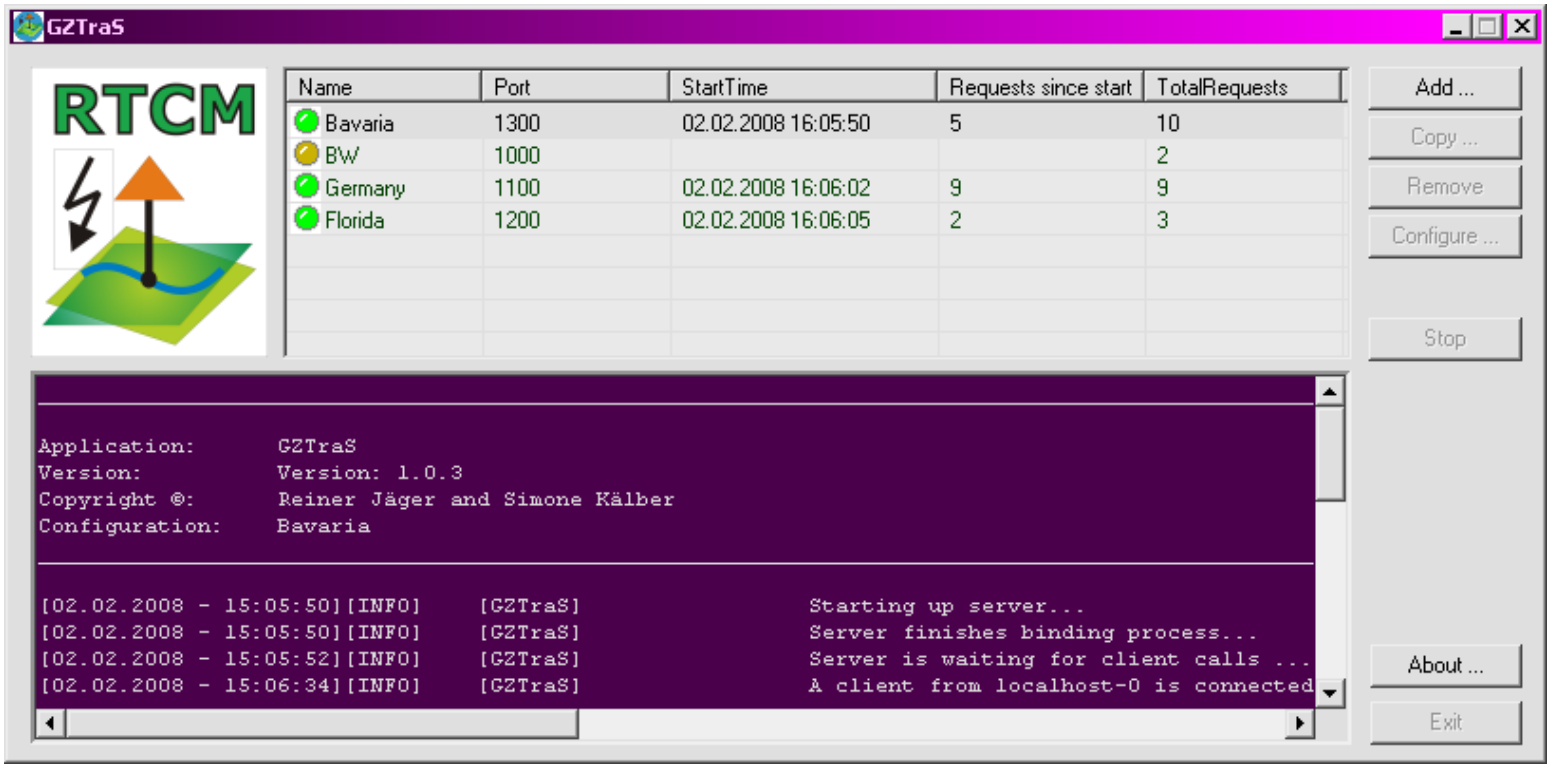
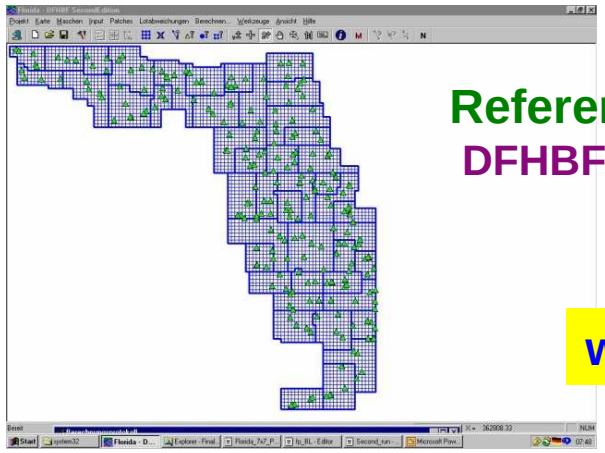
RCTM 3.1 Transformation Messages – GZTra-Server and GZTra-Client





Reference Transformations

DFHBF Florida

DFHBF Bavaria

DFLBF Bavaria

www.geozilla.de

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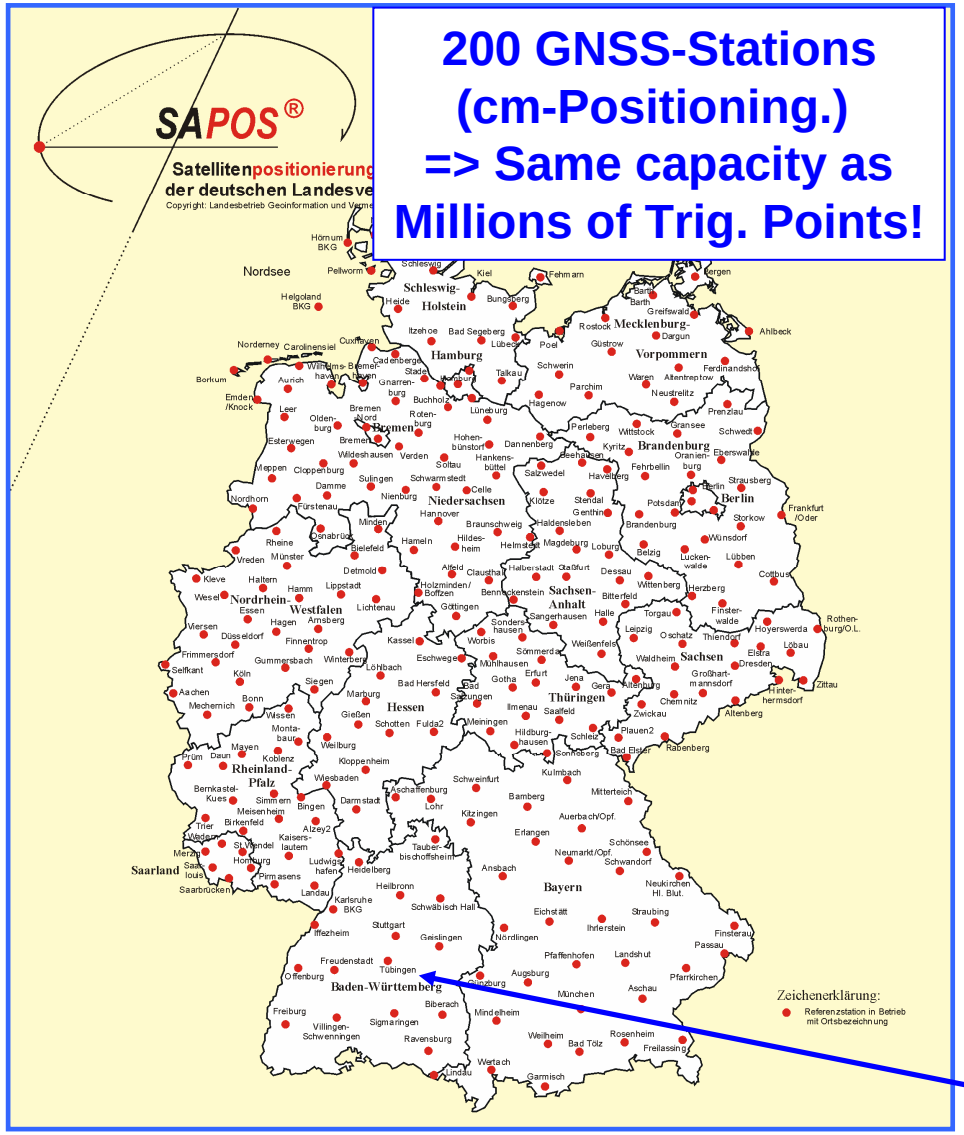
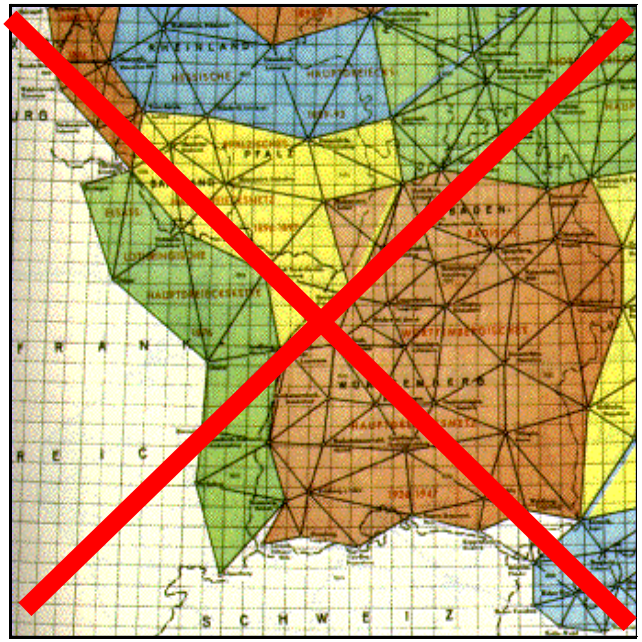
GNNS Reference Station Networks



200 GNSS-Stations (cm-Positioning.) => Same capacity as Millions of Trig. Points!

Old Classical Systems



Horizontal Positioning

ITRF-based datum => Direct access by GNSS (Old datum: GNSS online trafo)

Height

H(Physical) = h(GNSS) – N(Geoid)

~~(75% levelling points cancelled)~~

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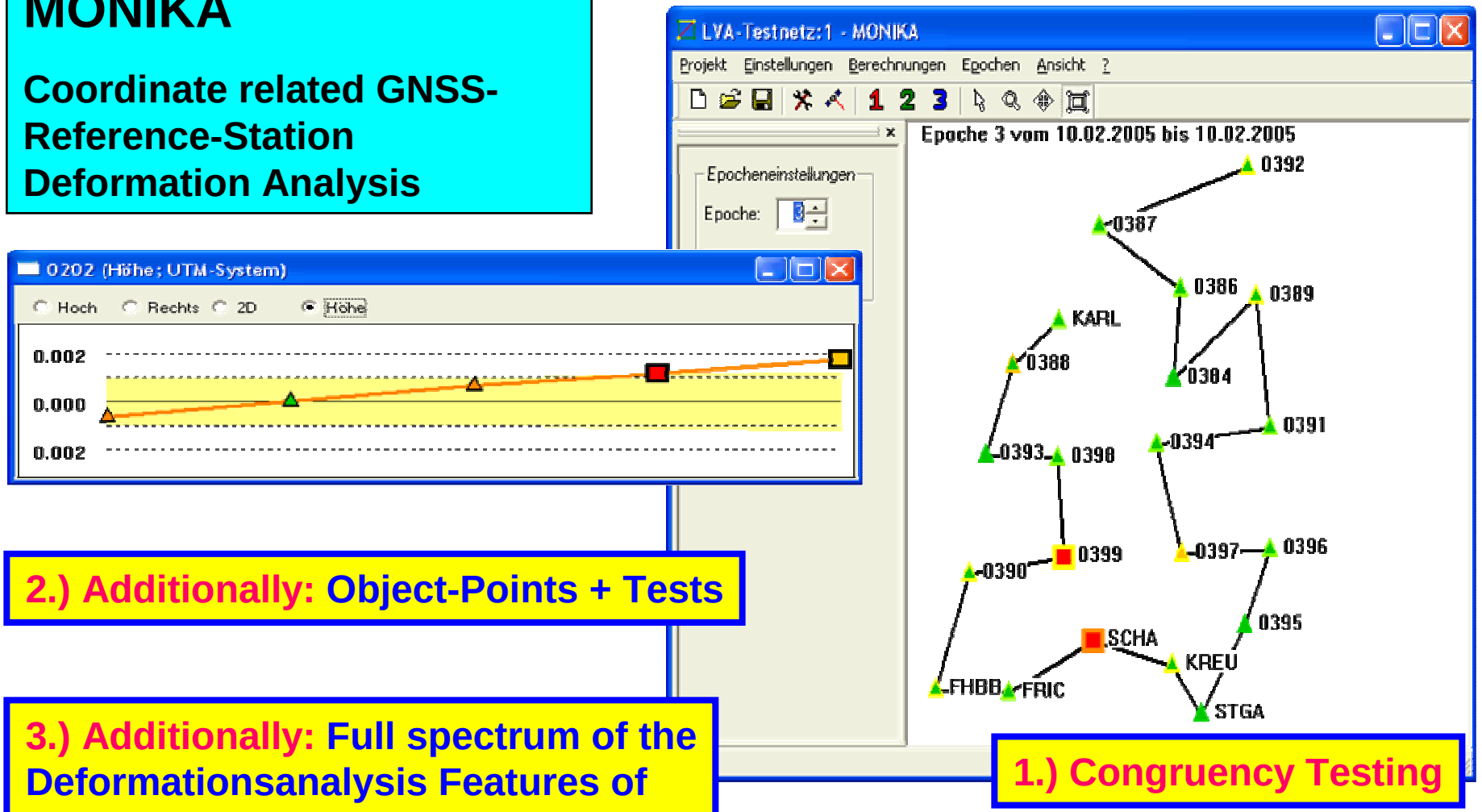
GNSS – Reference-Stations-Coordinate *MONI*toring *KA* Model - *MONIKA*

MONIKA

Coordinate related GNSS-Reference-Station Deformation Analysis



2.) Additionally: Object-Points + Tests

3.) Additionally: Full spectrum of the Deformationsanalysis Features of the GOCA-software (www.goca.info)

1.) Congruency Testing

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MOLDPOS – Scientific RaD-Project

=>

Provision of Geodetic Infrastructure for GNSS-Positioning-Service called MOL(D)POS

Computation of HRS and Transformation Parameter-Databases (DFHBF)

Computation of Horizontal Transformation Parameter-Databases (COPAG/DFLBF) for GNSS and GIS

GeoMonitoring and Early-Warning using GNSS-Reference Stations as Basic GeoSensornetwork (MONIKA, GOCA)

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Precise Monitoring and Navigation of Objects – Agriculture Applications

NTRIP
Datentransfer über
das Internet

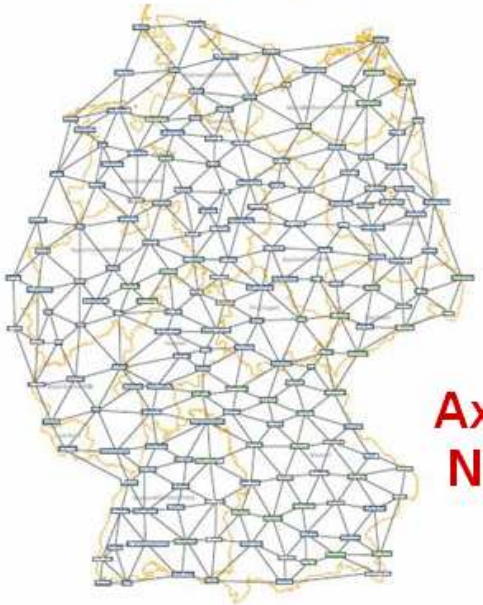
EUREF or IGS RTCM-Corrections

NTRIP-Format

Mobile Internet (USB-Stick) and InterNet GNSS-Radio

JOHN DEERE

Hochschule Karlsruhe
Technik und Wirtschaft
UNIVERSITY OF APPLIED SCIENCES



Ort	Basislinie [km]	Beobachtungsdauer [min]	EUREF IP		John Deere MRTK	
			Nord [m]	Ost [m]	Nord [m]	Ost [m]
Karlsruhe	ca. 20km	15 Minuten	0,0513	0,0604	0,0072	0,0055
Dresden	ca. 430km	15 Minuten	0,1657	0,2758	0,0088	0,0062
Warnemünde	ca. 610km	15 Minuten	0,1033	0,0742	0,0098	0,0054

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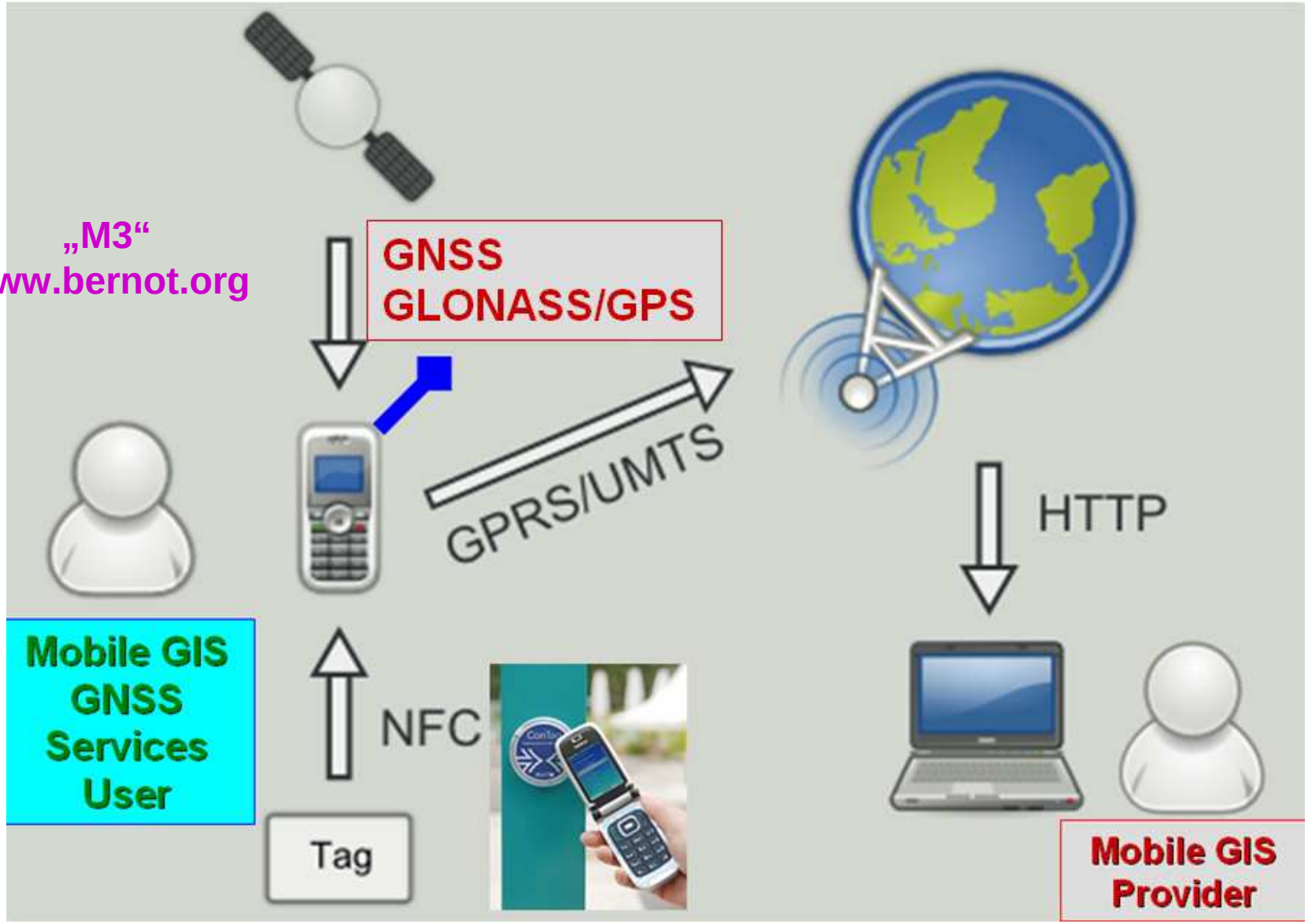
Precise Monitoring and Navigation of Persons and Objects



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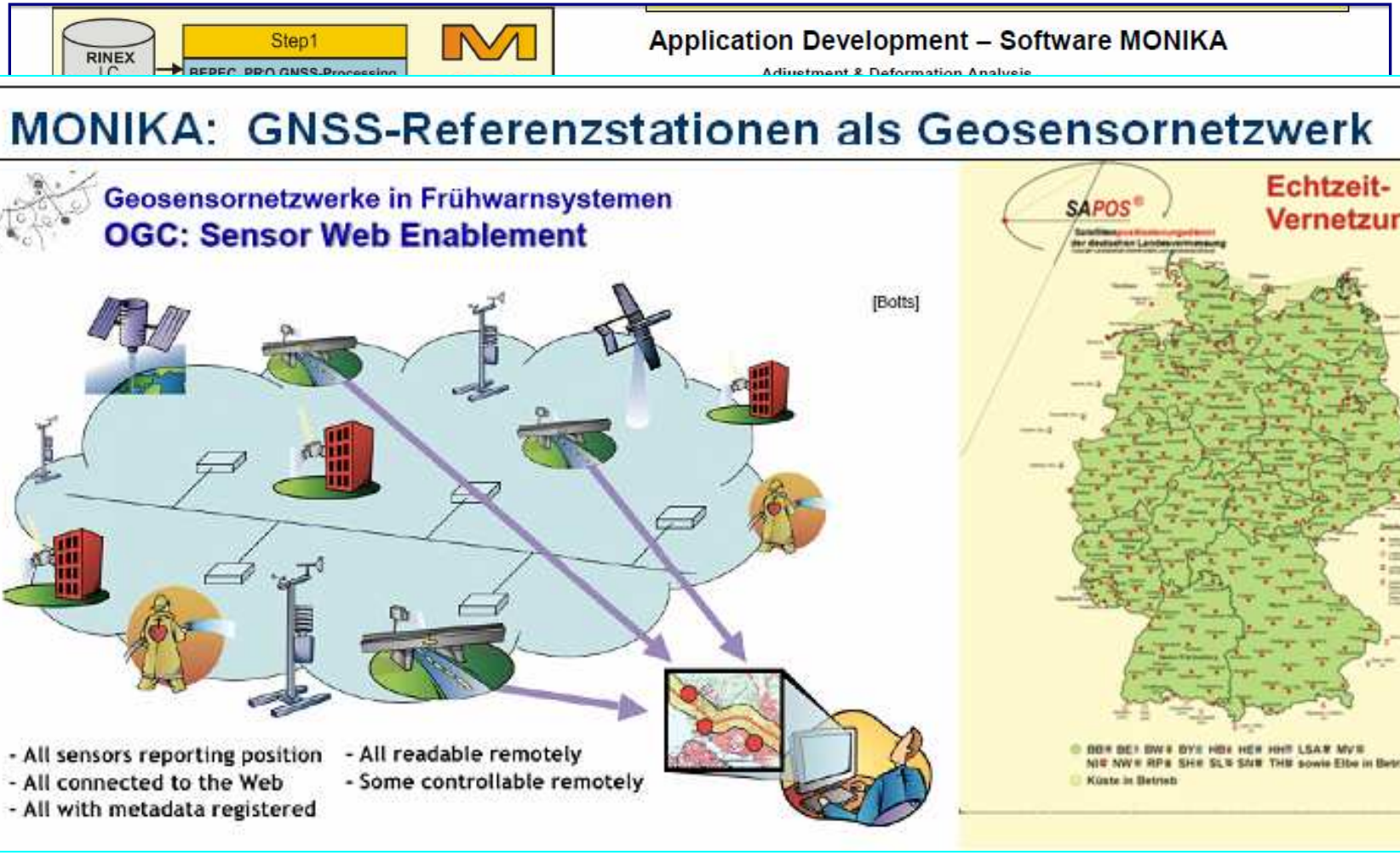
Deformation Integrity Monitoring for GNSSPositioning Services including a Scalable Hazard Monitoring by the Karlsruhe Approach (MONIKA)



www.monika.ag

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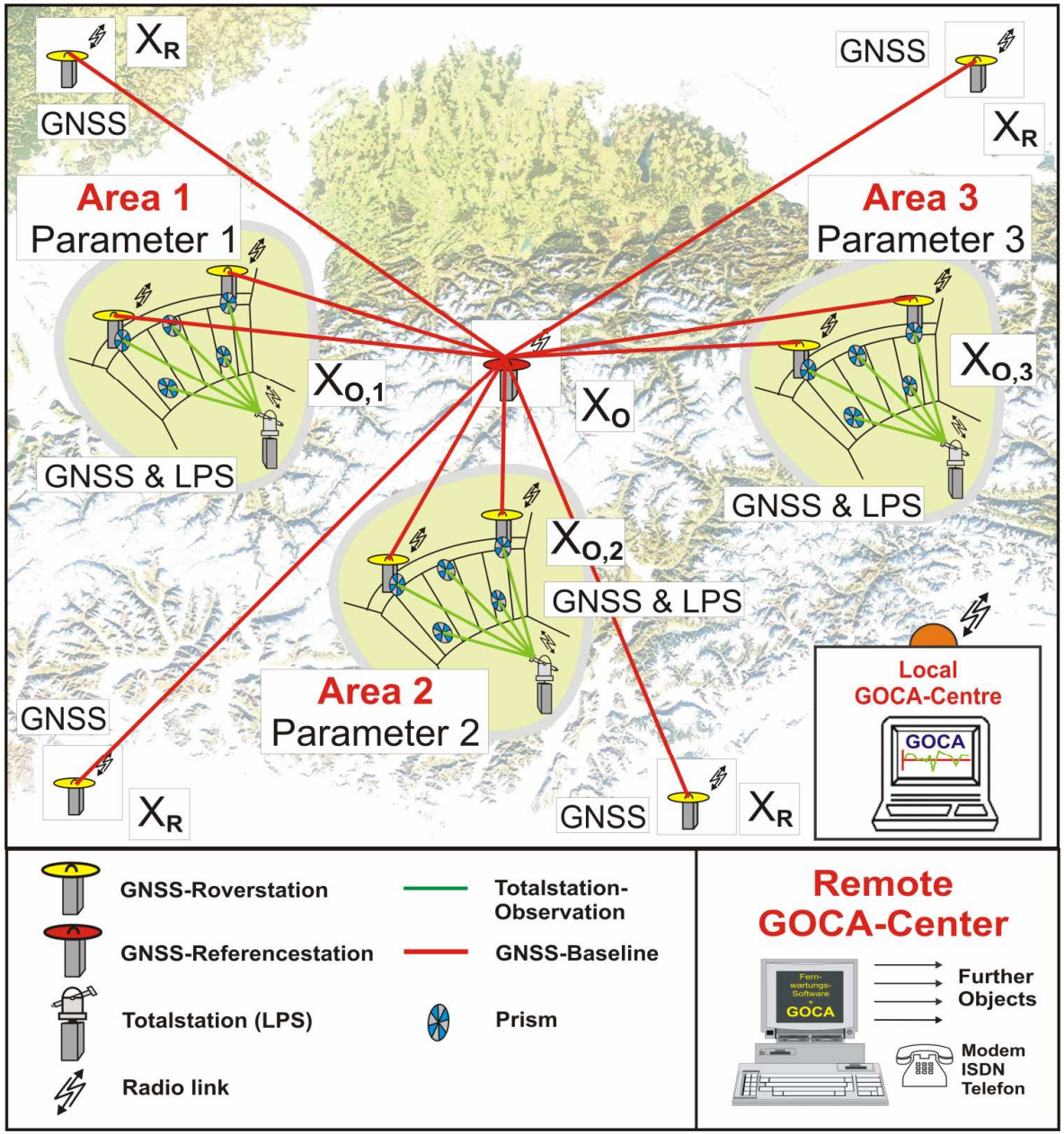
GOCA-Software Version 4.0

Scalable Design and Modelling

- **Pure GNSS Array**
- **Pure LPS Array**
- **GNSS & LPS Array**
  - Several Regional/Local Areas
  - GNSS as Reference Frame X_R
  - Special Case: 1 Area



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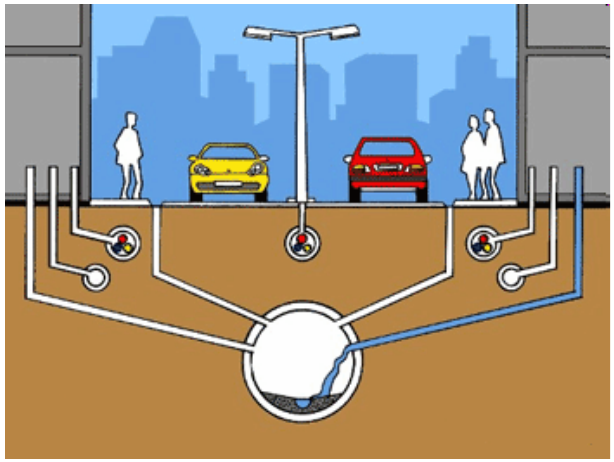
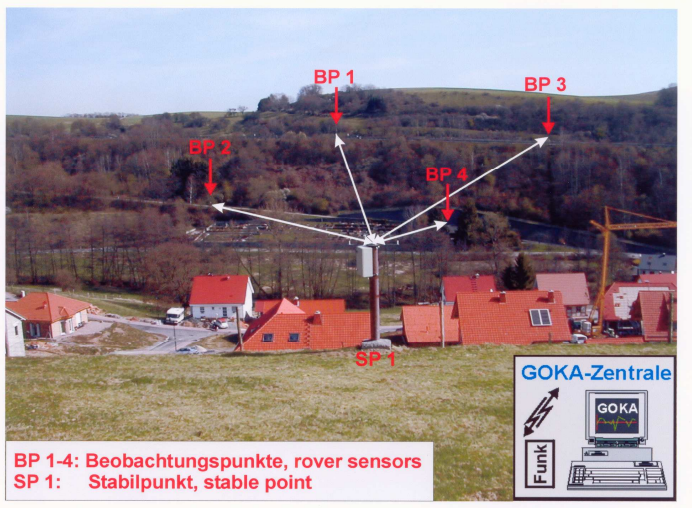
GOCA - Geodetic – Monitoring – Deformationanalysis and Alarming

Natural Phenomena - Mining- / Geotechnical , Building - Monitoring

Dam-Monitoring (ICOLD, 80.0000



Tunnels / Bridges



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Solutions – GNSS-Satellite Navigation and Mobile IT
www.galileo-bw.de

BOSCH
Technik fürs Leben

Hochschule Karlsruhe
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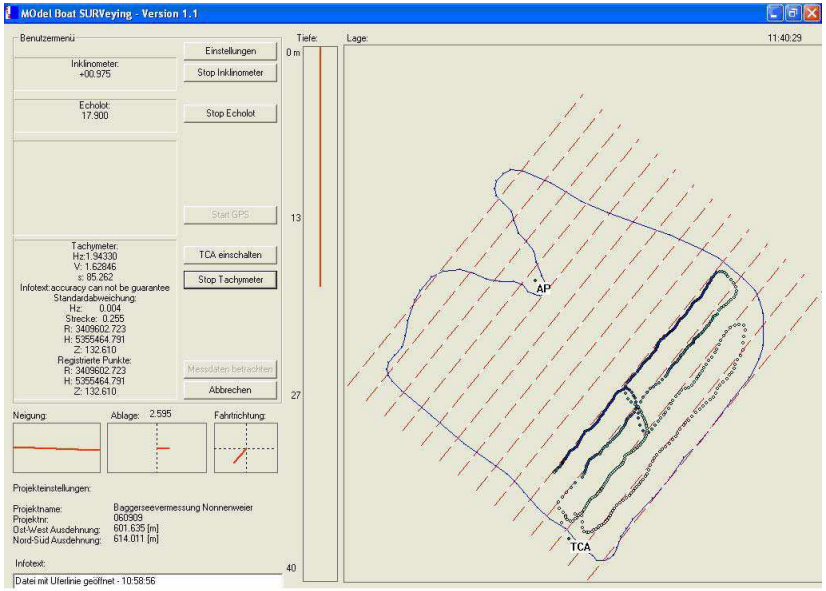
GNSS/INS Drones

Autonomous drones (below) for documentation of the state of different kind of facilities



Autonomous GNSS- bzw. GNSS/INS-boatsdrone for hydrological application (right up and right down)

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GNSS-Further Developments & Trends – Platform Orientation

Dataacquisition with GNSS/INS-positioned and oriented Multisensor-Plattforms

Development of GNSS/INS-based Datenquisition-Systems in Cooperation with Industry

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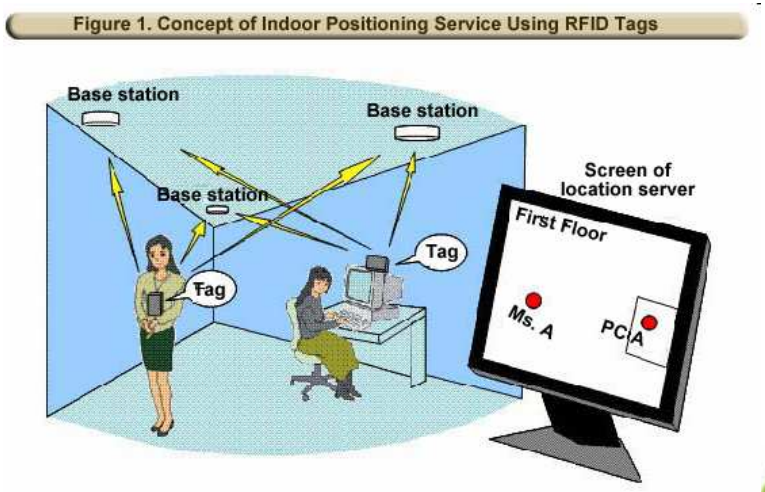
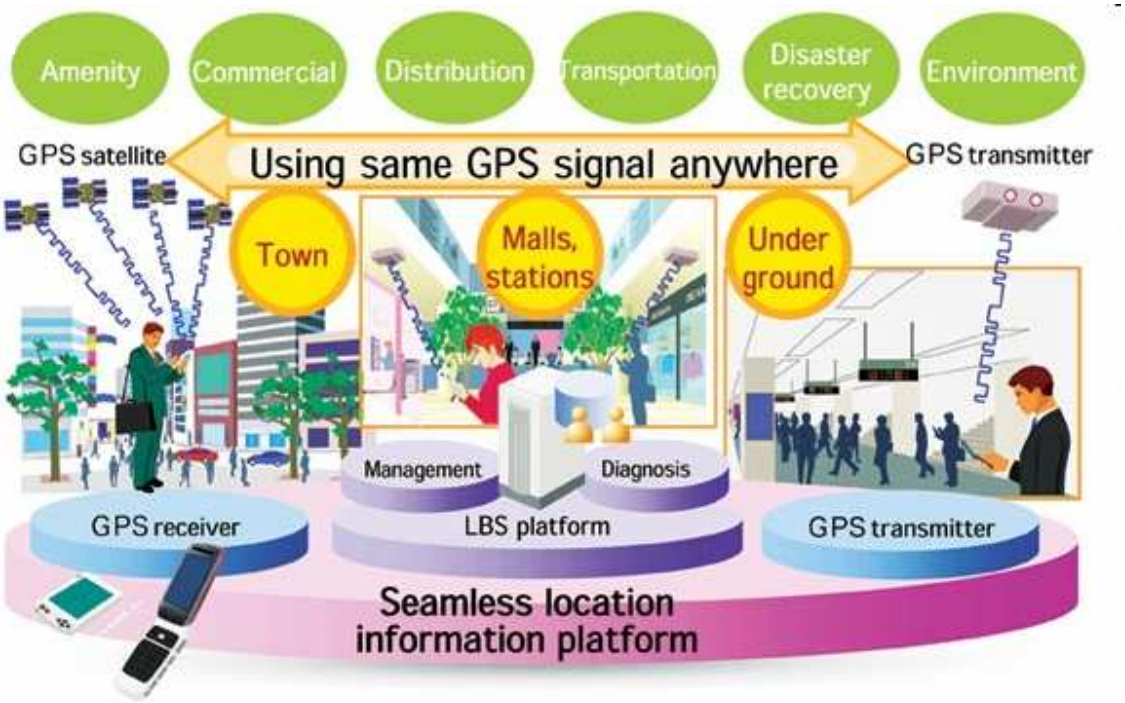
GNSS-Further Developments&Trends – Seamless Out-/Indoor Positioning



- Seamless Indoor-Outdoor-Positionierung
- Developments with Industry

  www.galileo-bw.de

  www.afusoft.com



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