Geo++® GNSMART – Modulare Architektur für kundengerechte Korrekturdatendienste

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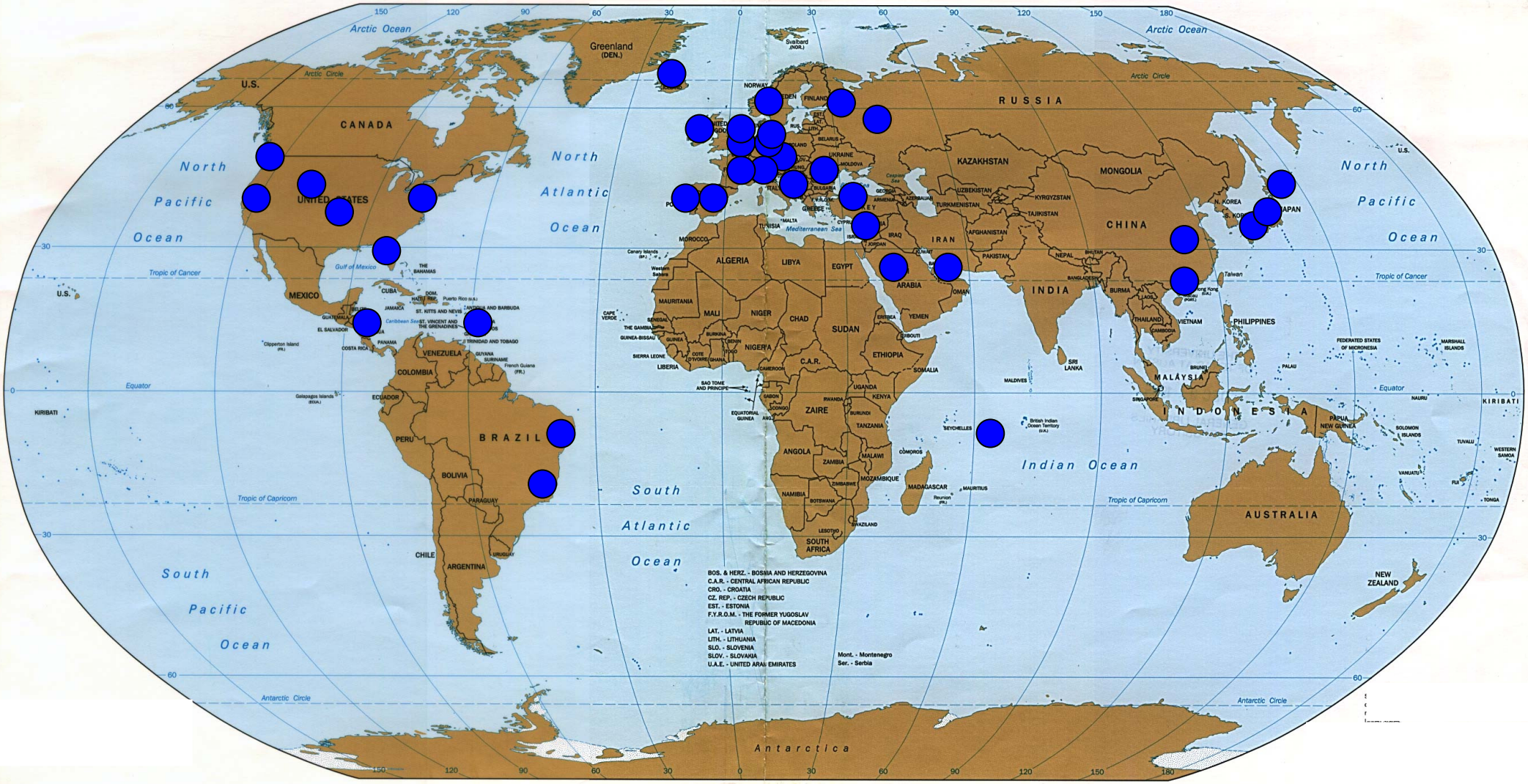
Geo++® Worldwide Business



● Geo++ Products in use 1990-2006

Einführung

GNSS-SMART =

Global Navigation Satellite System

State Monitoring And Representation Technique

Technik

- zur Bestimmung (State Monitoring) und
- zur Bereitstellung (Repräsentation)

des System Zustands von GNSS Systemen

GNSMART

= Geo++ Software Implementation von GNSS-SMART

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GNSS Prinzip

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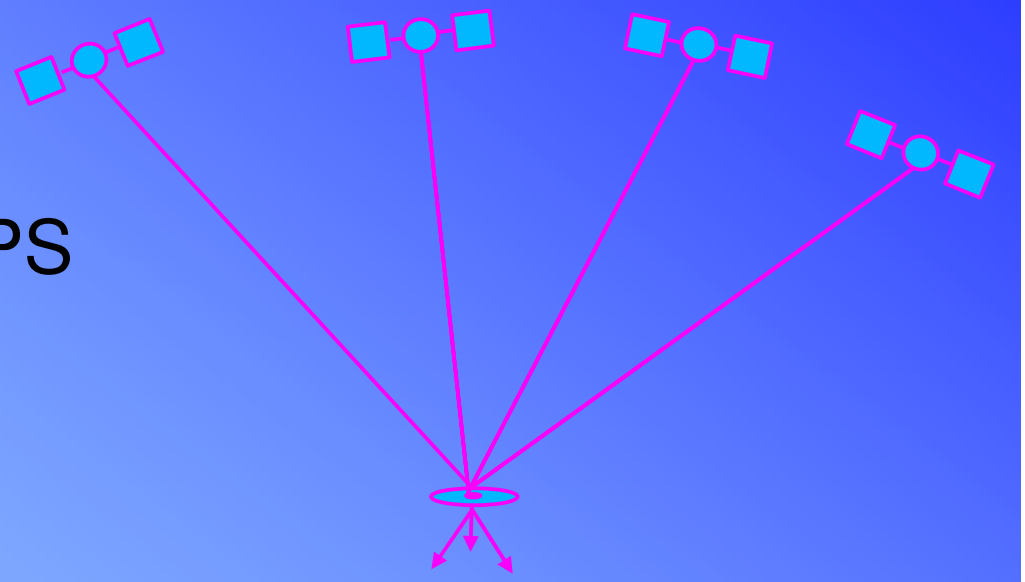
Absolute Positionierung

- Positionsbestimmung eines einzelnen (“Stand-Alone”) GNSS Empfängers im System des GNSS



- Absolute Genauigkeit mit GPS
  - 3 – 10 m
  - für viele Anwendungen unzureichend
- voller Einfluß aller Fehlerquellen

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Fehlerquellen

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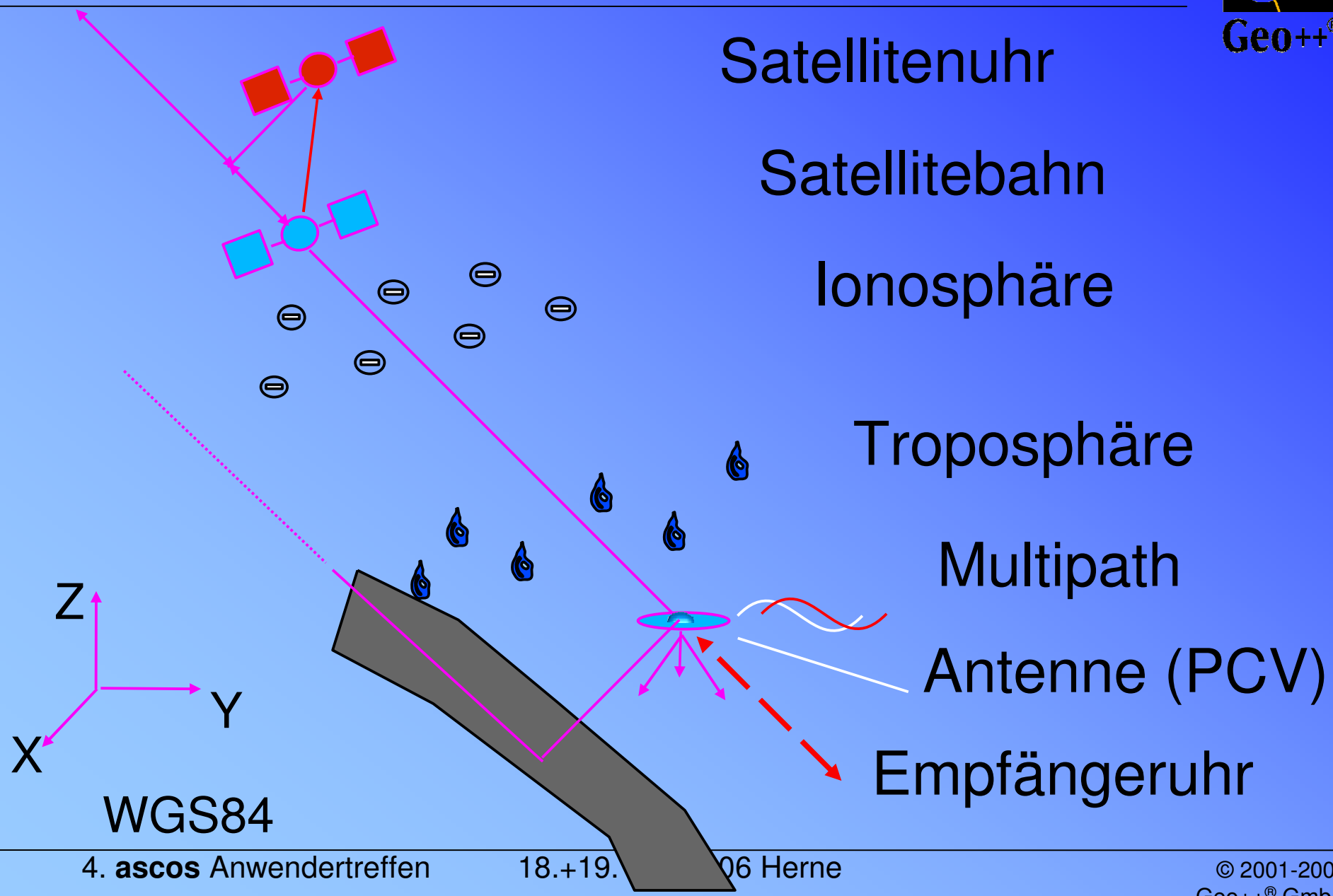
GNSS Fehlerquellen



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Größenordnung der Fehlereinflüsse

Error Source	Absolute Influence
Satellite Orbit	2 ... 50m
Satellite Clock	2 ... 100m
Ionosphere	0.5 ... >100 m
Troposphere	0.01 ... 0.5 m
Multipath Code	m
Multipath Phase	mm ... cm
Antenna	mm ... cm

-> total: 5 ... 20 m

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Differential GNSS

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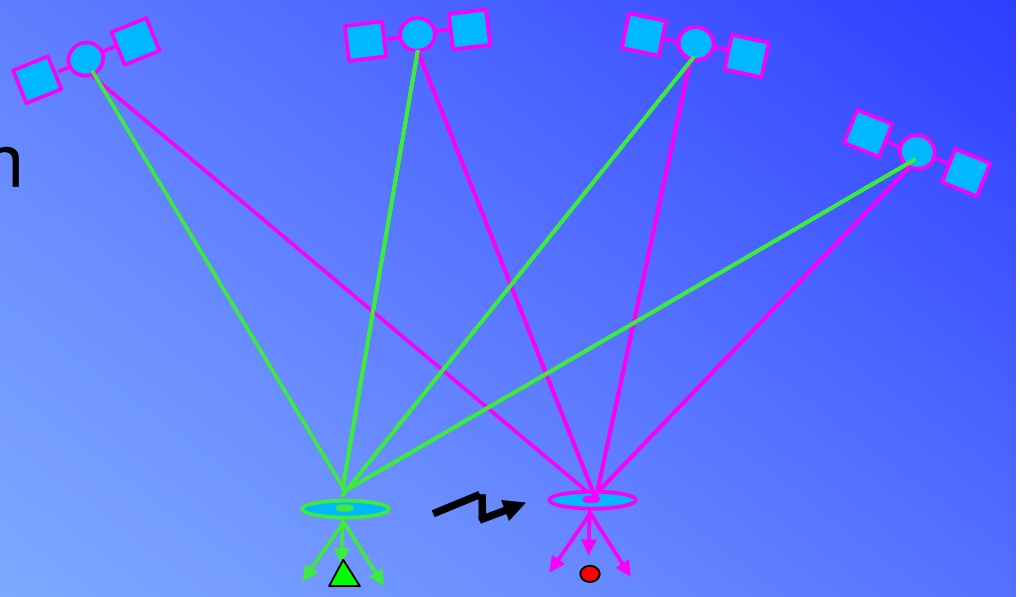
Differential („DGNSS“) Positionierung

- Bestimmung der Fehlersumme auf bekannter Station
  → „Korrekturen“
- Übermittlung der Korrekturen an den „Rover“
- Anbringen der Korrektiuren
  → Reduktion der Fehler
- Berechnung der Position
  - Mit Codes („DGNSS“) oder
  - mit Trägerphasen („RTK“)



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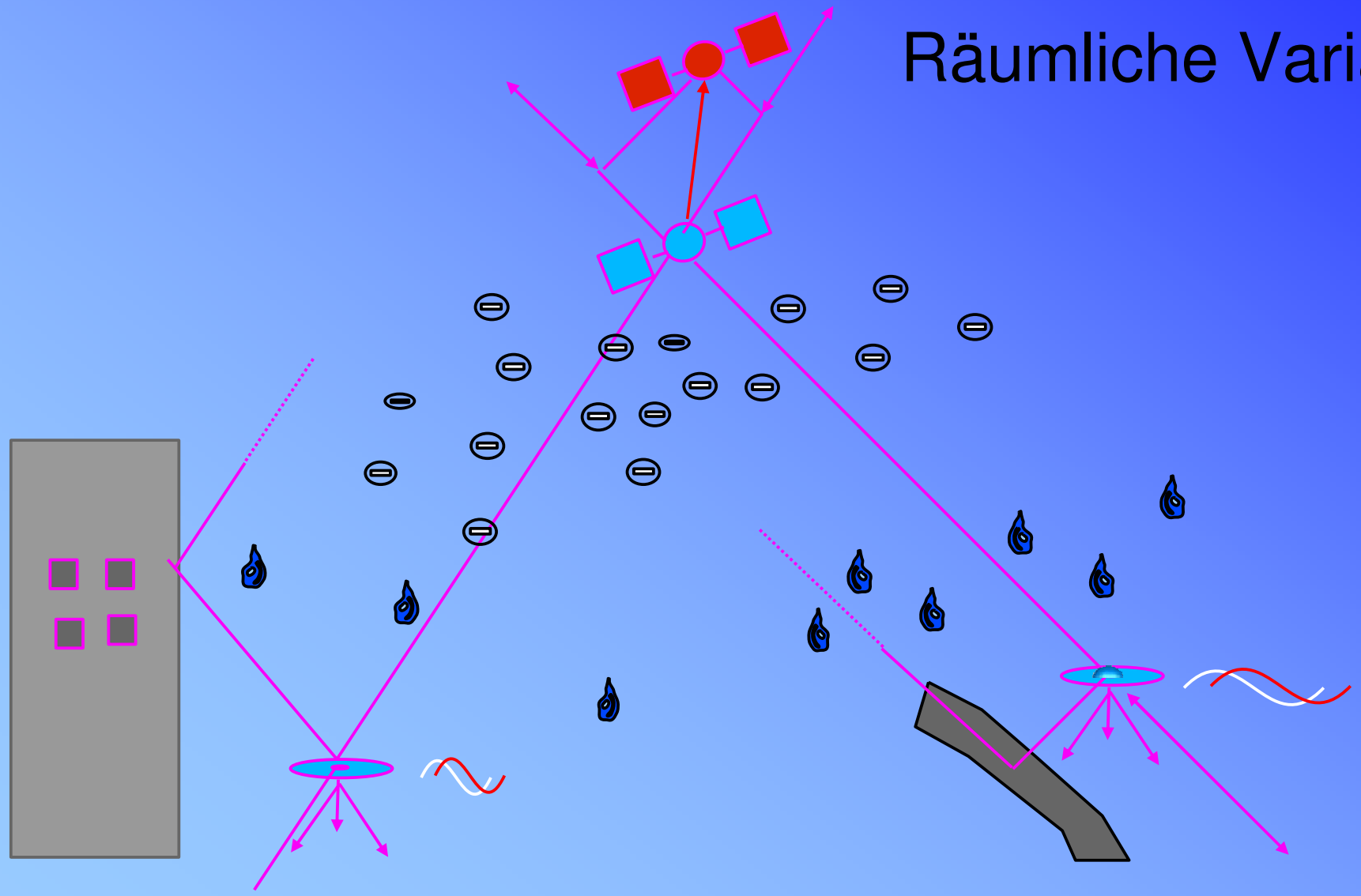
DGNSS Fehlerquellen

Räumliche Variationen



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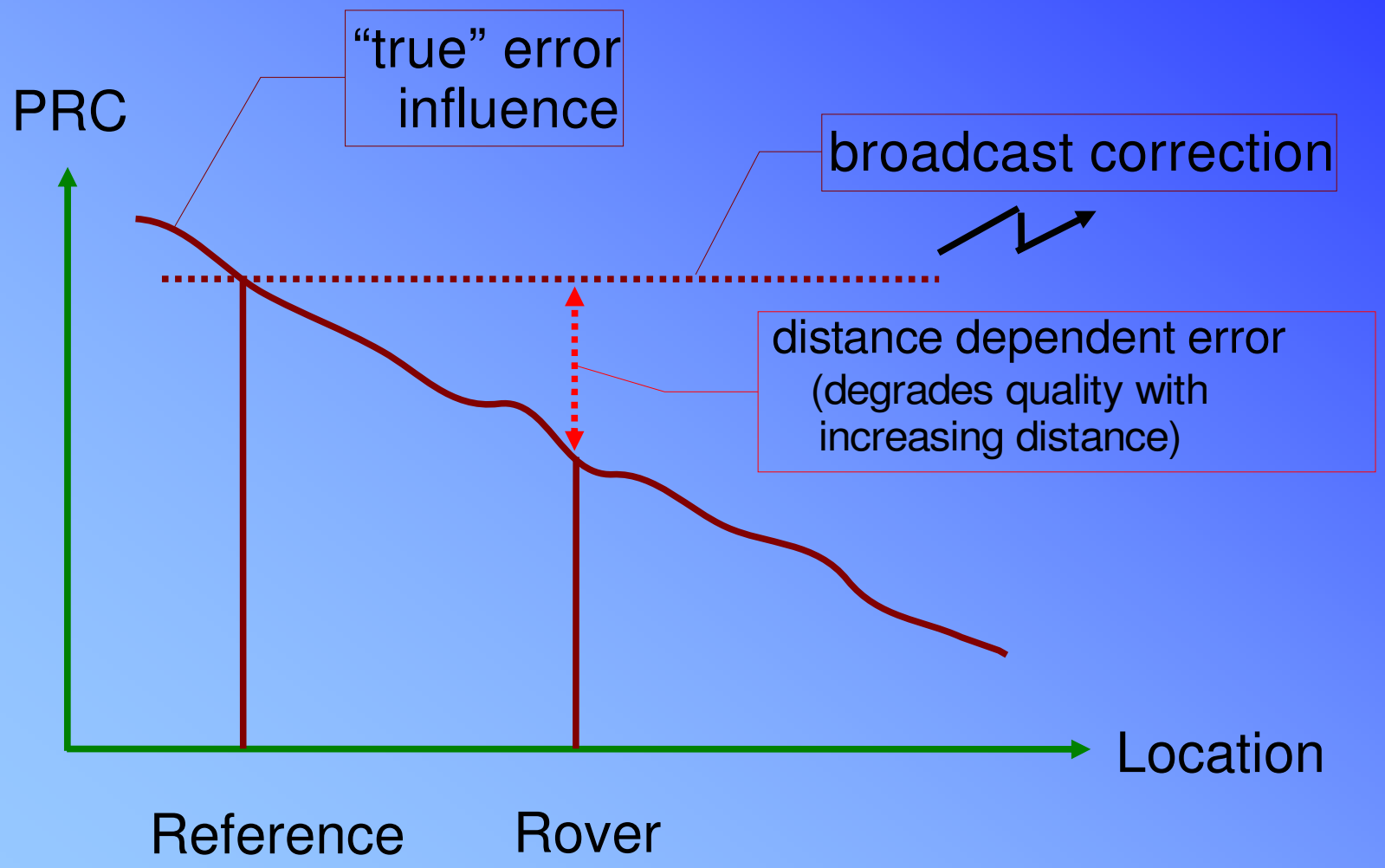
DGNSS/RTK
Entfernungsabhängigkeit



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Größenordnung relativer Fehlereinflüsse

Error source	Absolute influence	Relative influence
Satellite Orbit	2 ... 50m	0.1 ... 2 ppm
Satellite Clock	2 ... 100m	0.0 ppm
Ionosphere	0.5 ... >100 m	1 ... 50 ppm
Troposphere	0.01 ... 0.5 m	0 ... 3 ppm
Multipath Code	m	m
Multipath Phase	mm ... cm	mm ... cm
Antenna	mm ... cm	mm ... cm
	-> total:	1...2 cm + 1...20 ppm

Hohe räumliche Korrelation

Lokal (Kalibrierung)

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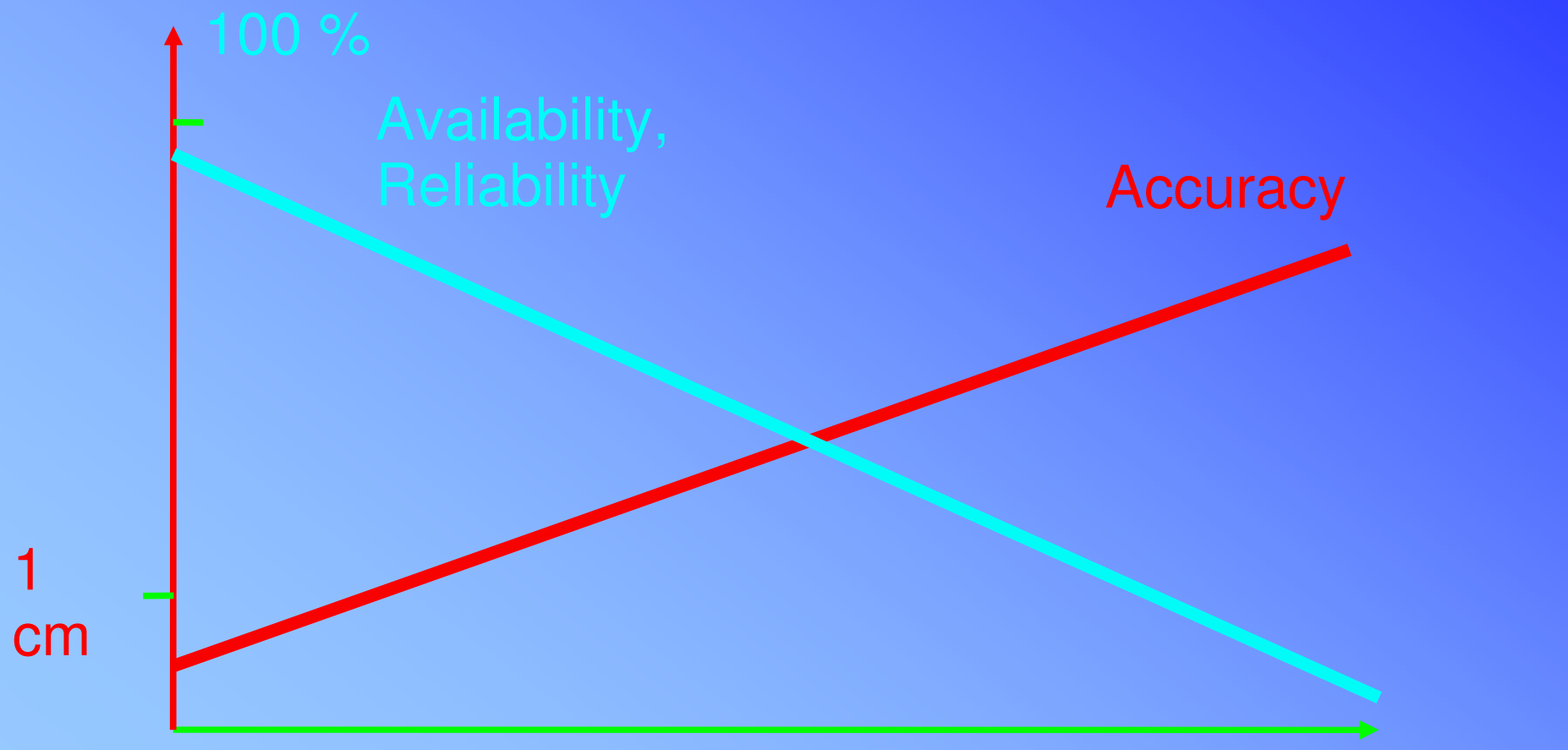
RTK: Genauigkeit, Zuverlässigkeit, Verfügbarkeit

Einfluss entfernungsabhängiger Fehler



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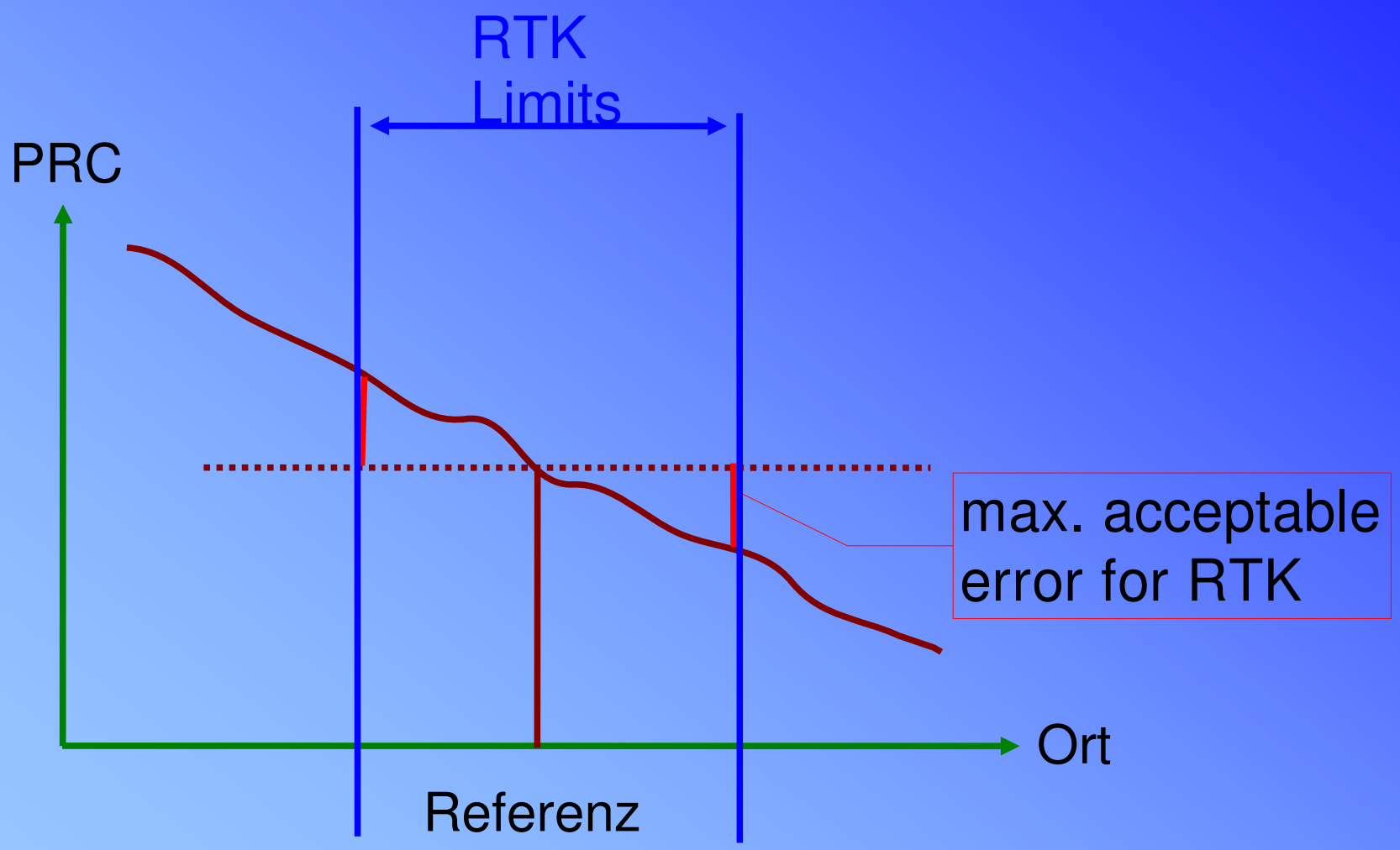
RTK-Begrenzung



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Netz einzelner Referenzstationen

Accuracy, Reliability, Availability

Good — Bad

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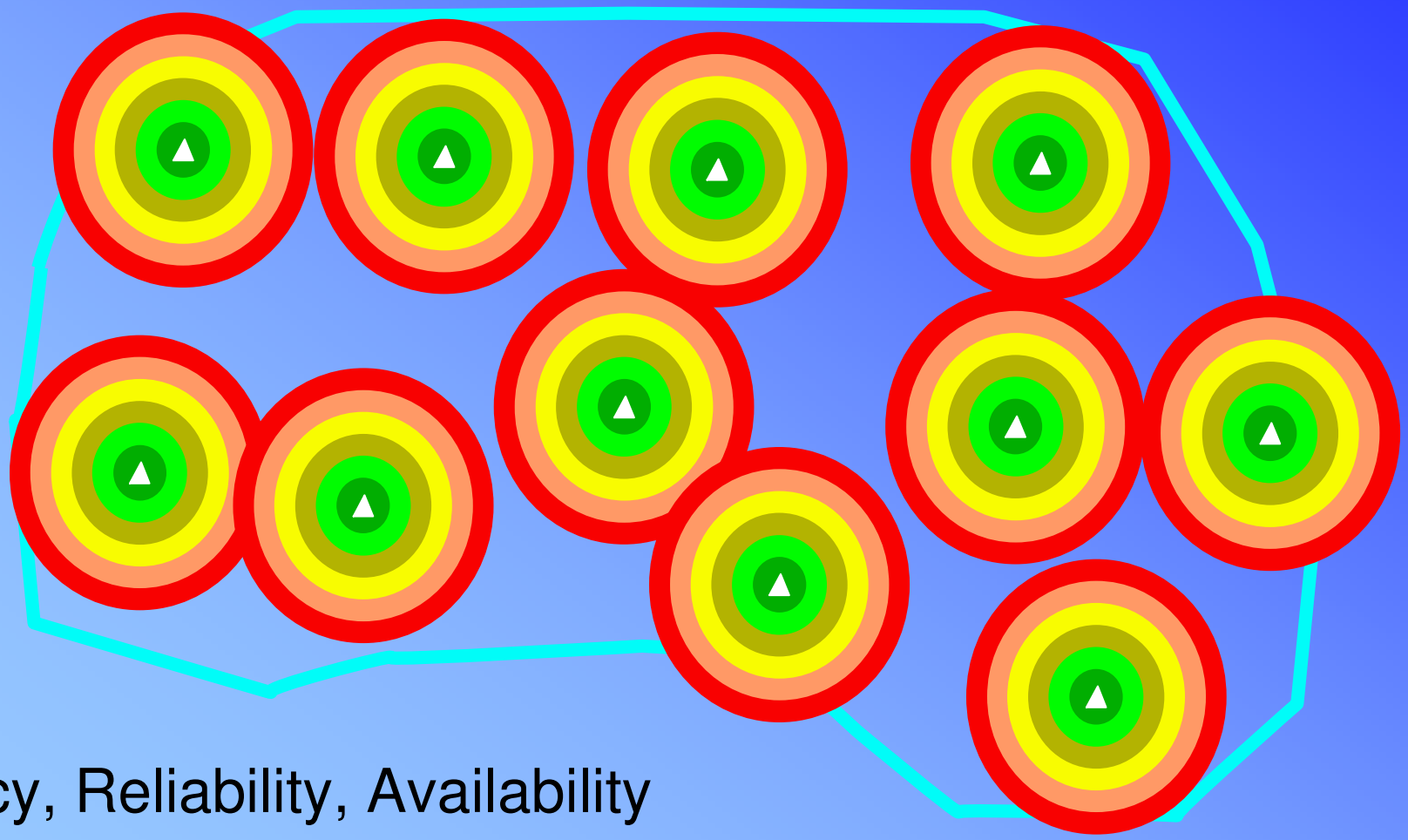
Stand Alone Reference Stations



Accuracy, Reliability, Availability

Good Bad

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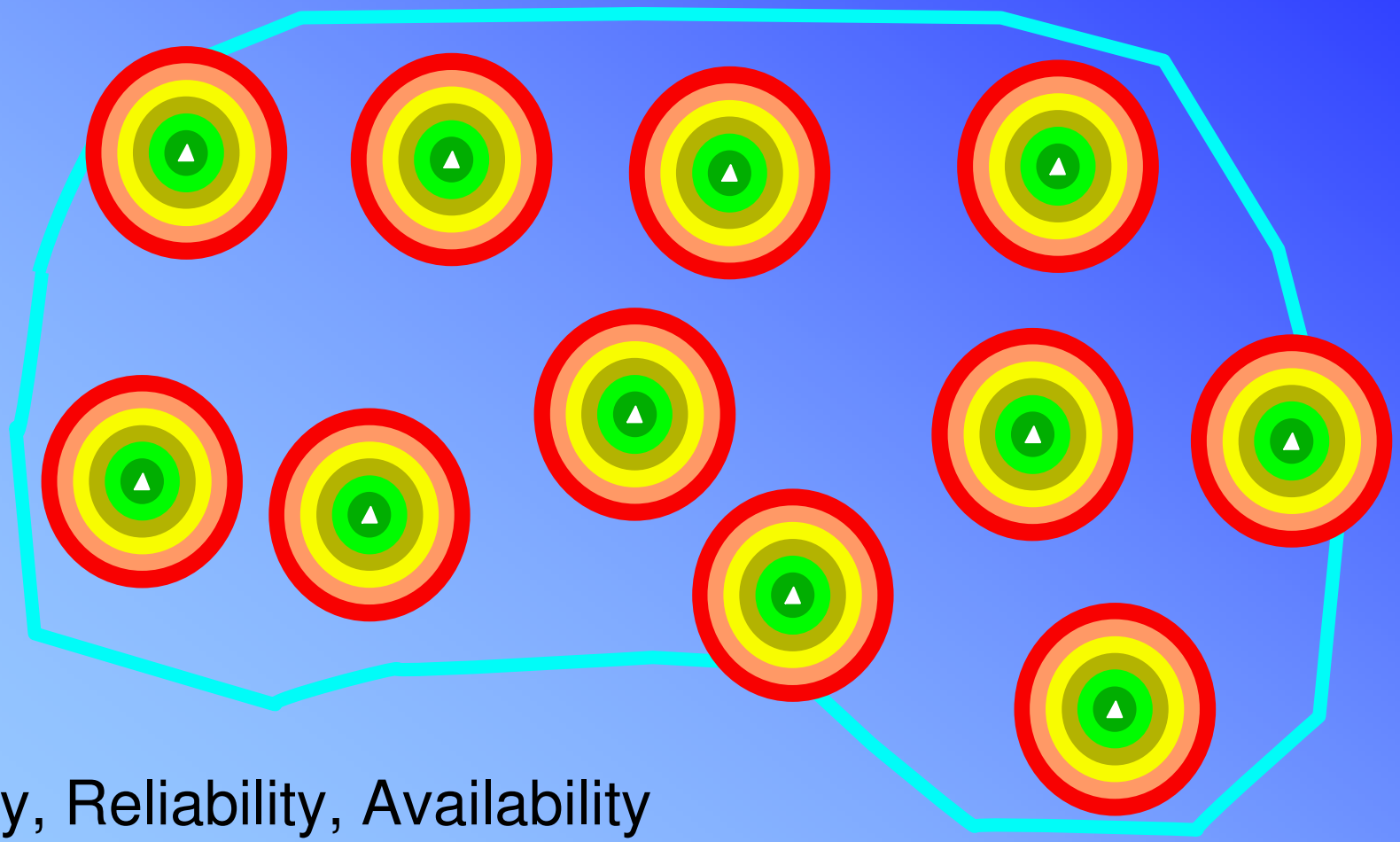
Stand Alone Reference Stations



Accuracy, Reliability, Availability

Good Bad

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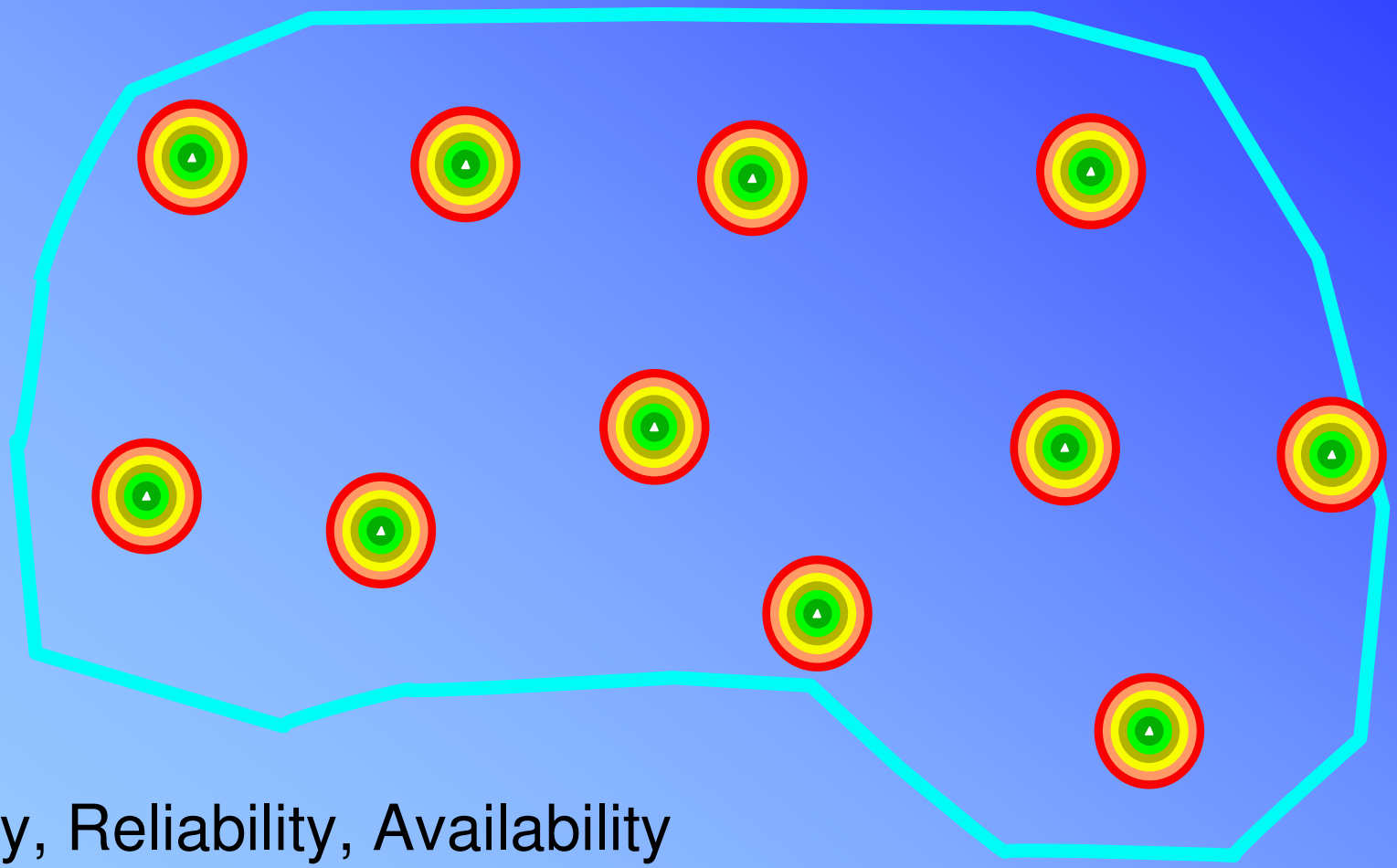
Stand Alone Reference Stations



Accuracy, Reliability, Availability

Good Bad

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RTK Netze

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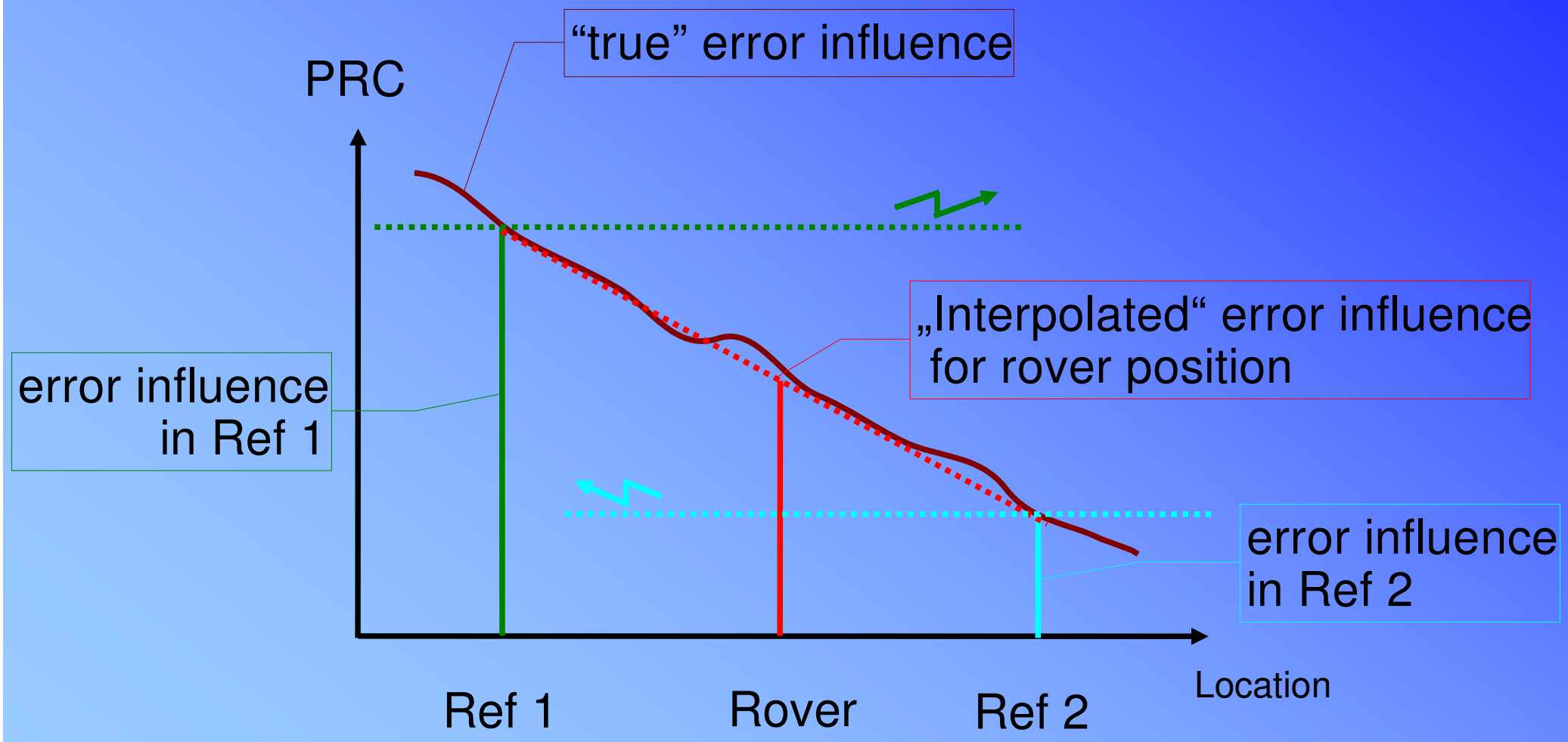
Interpolation entfernungsabhängiger Fehler



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GNSS-SMART Network

Accuracy, Reliability, Availability

Good Bad

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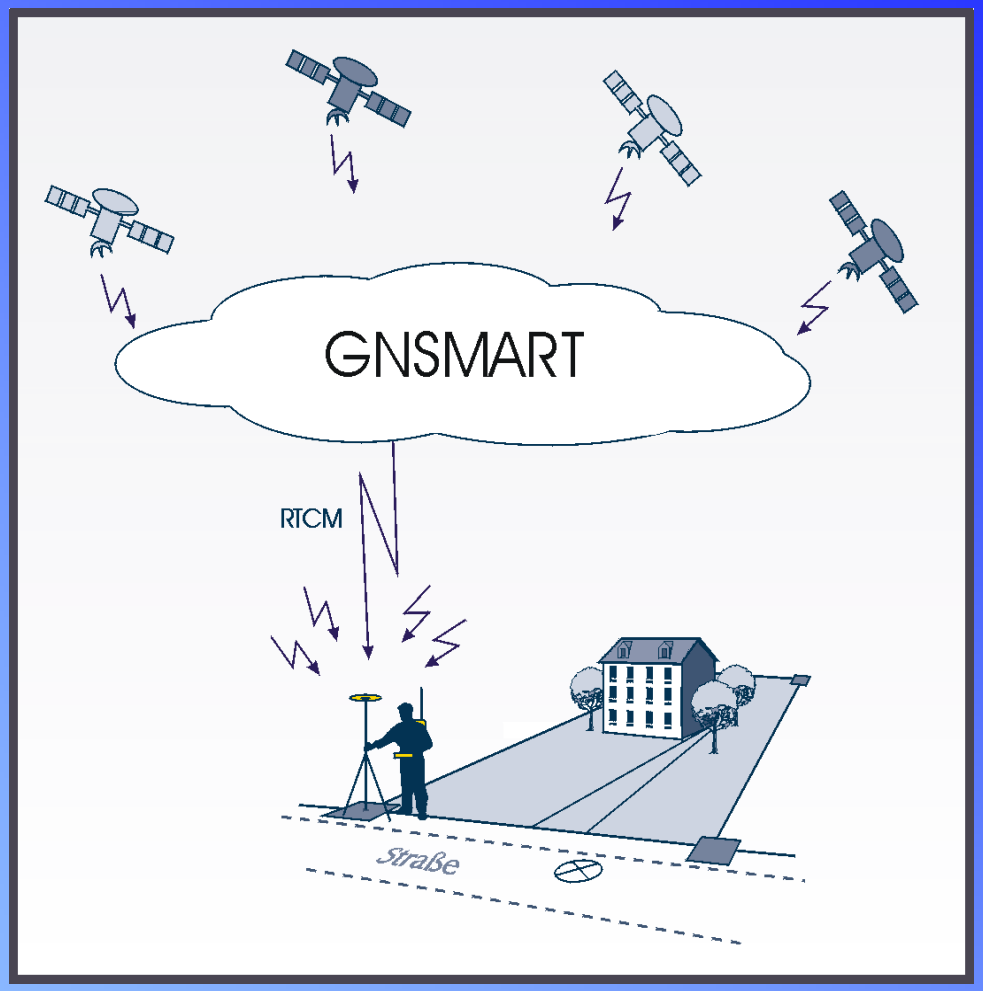
GNSMART: Nutzer-Sicht

- **user in the field**
  - **one way** communication link
  - **receive** all necessary correction/reference data
  - **determine absolute RTK position**
  - **anytime/anywhere**
- **1 cm** accuracy



1 cm accuracy - everywhere!

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Network RTK: Aufgaben der Netzwerksoftware

- primary task (pre-requisite): State Monitoring
  - determine distance (and site) dependent errors
  - carrier phase ambiguity resolution
- secondary task: Representation
  - represent network information for user
    - distance dependent errors
      - orbit, ionosphere, troposphere
    - reference station dependent errors
      - multipath, antenna, clock
  - using adequate formats (RTCM, FKP, VRS, SSR)

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Trägerphasenmehrdeutigkeit

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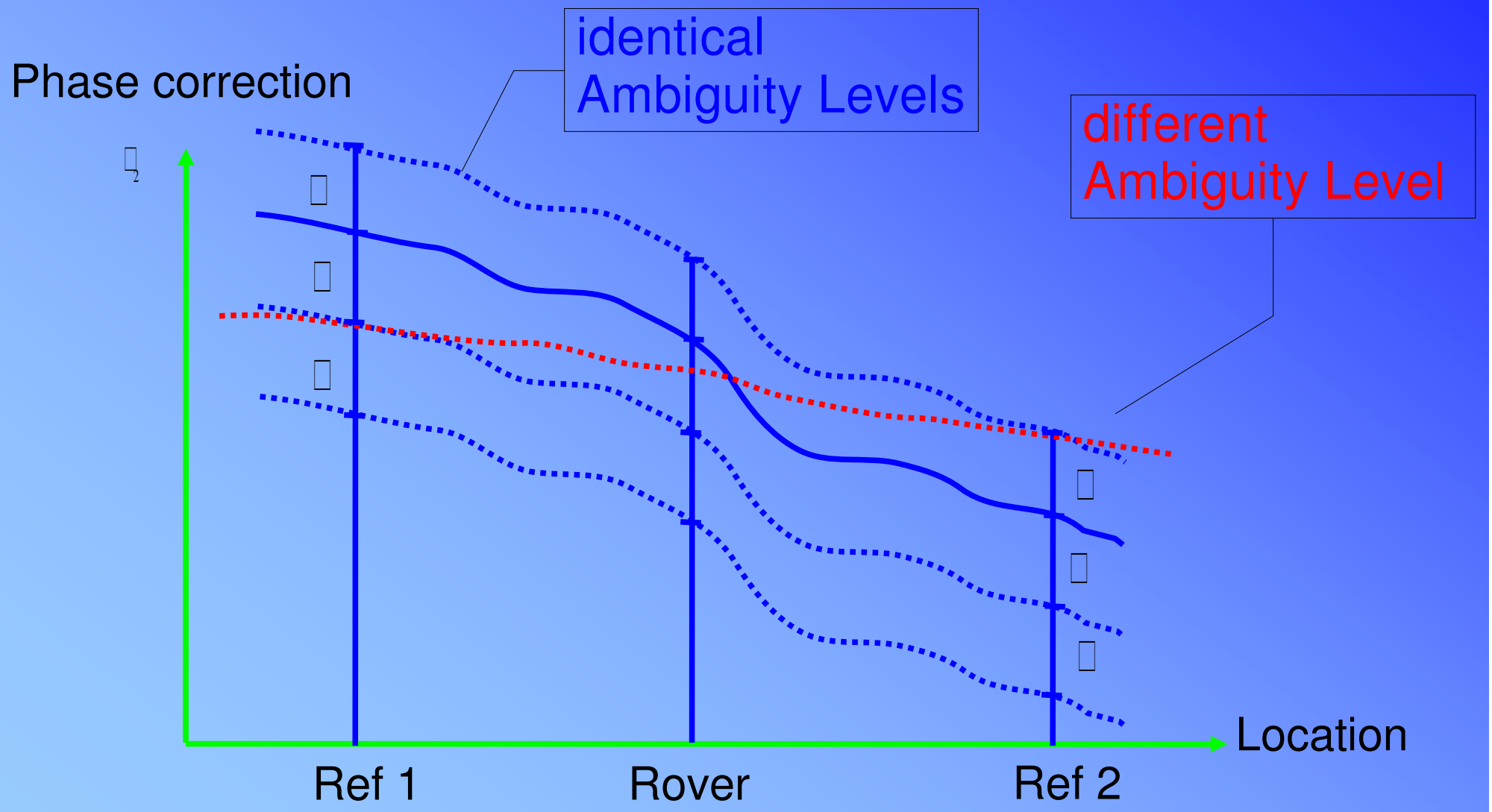
Mehrdeutigkeitsniveau

Ambiguities must be resolved to determine Distance Dependent Errors



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GNSMART State Monitoring

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GNSMART State Monitoring

- Vollständiges Zustandsmodell (State Space Model) (SSM) für alle Fehlerquellen
- mit Trägerphasengenauigkeit
- Multi-Stations Netz-Lösung (Redundanz)
- Multi-GNSS (GPS,GLONASS,SBAS,(Galileo,QZSS)
- undifferenzierte Beobachtungen
  - Codes (P1,P2,C/A) und Phasen (L1,L2,LA)
  - L5, E5a, E5b, E5a+b, E6
- undifferenzierte Mehrdeutigkeitslösung

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Mehrdeutigkeitslösung

- GNSS Fehlermodellierung benötigt
  - korrektes Mehrdeutigkeitsniveau
- -> **Mehrdeutigkeiten lösen**

- Mehrdeutigkeitslösung braucht
  - genaue Beobachtungen
  - “bias-free” Beobachtungen
- -> **GNSS Fehler müssen modelliert werden**

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GNSMART
Repräsentation

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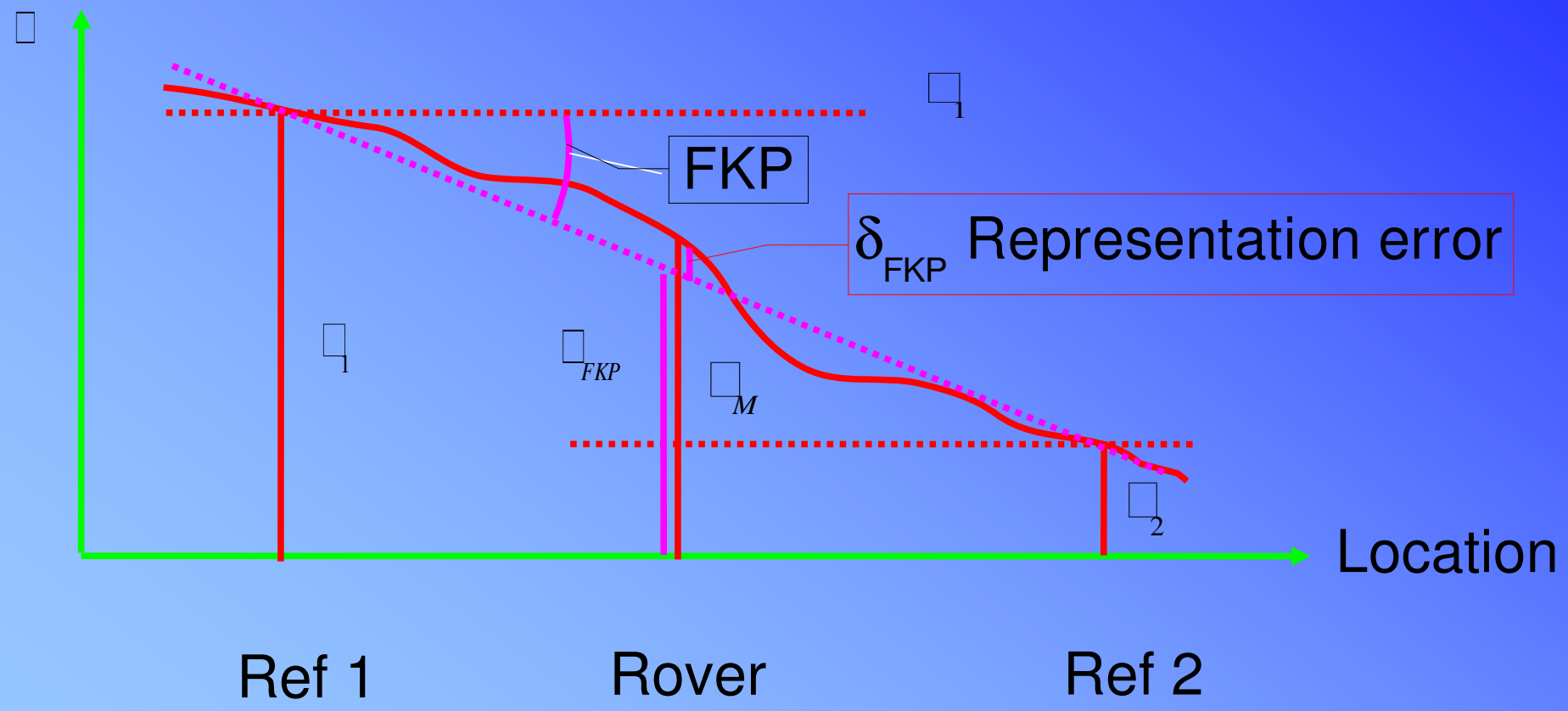
FKP Repräsentation

Phase correction



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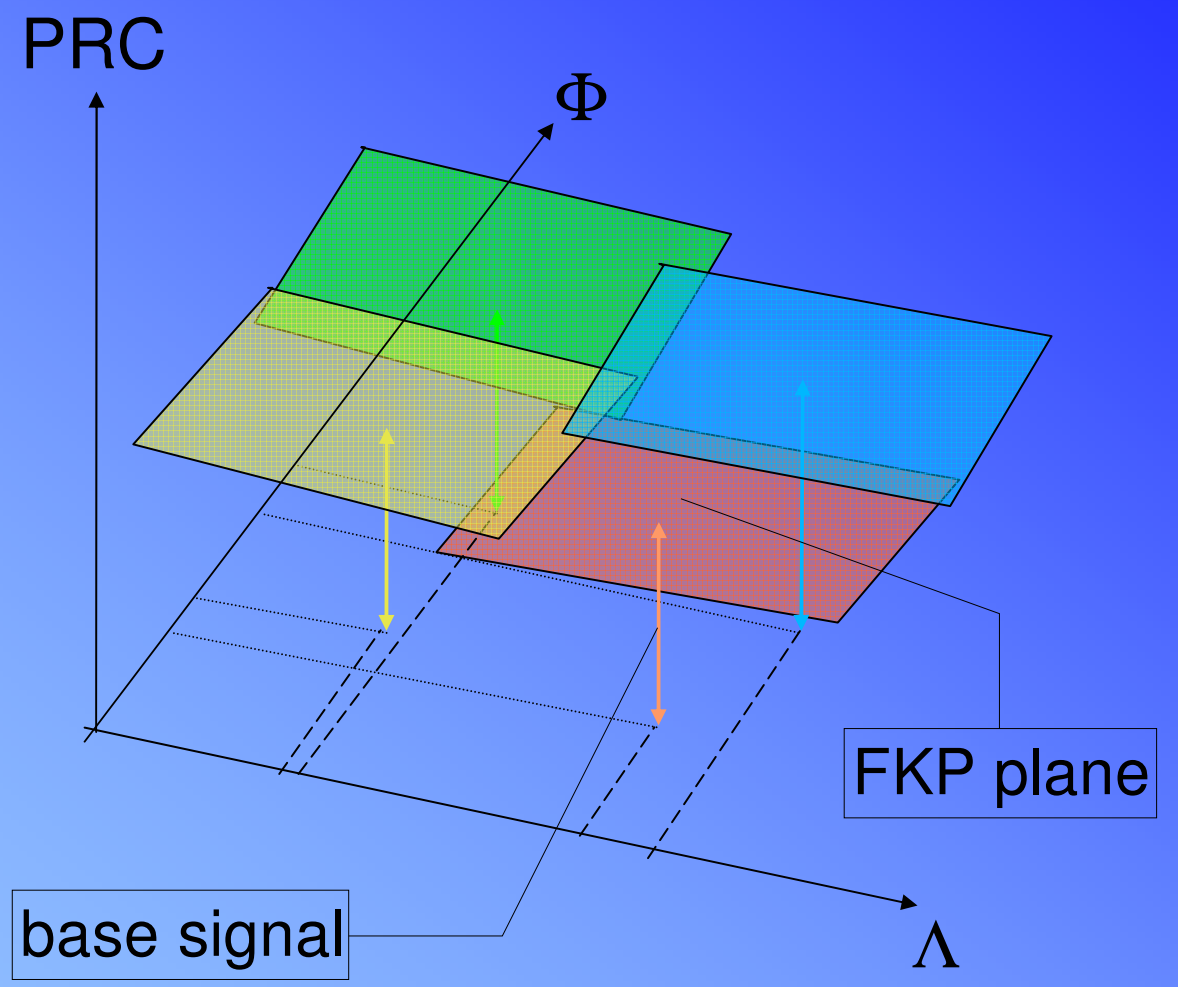
FKP Repräsentation

- ***base signal of reference station (corrections)***
- ***one linear FKP plane for each***
  - ***reference station***
  - ***signal (L_i, L_0)***
  - ***Satellite***
- ***optional: higher order polynomials***



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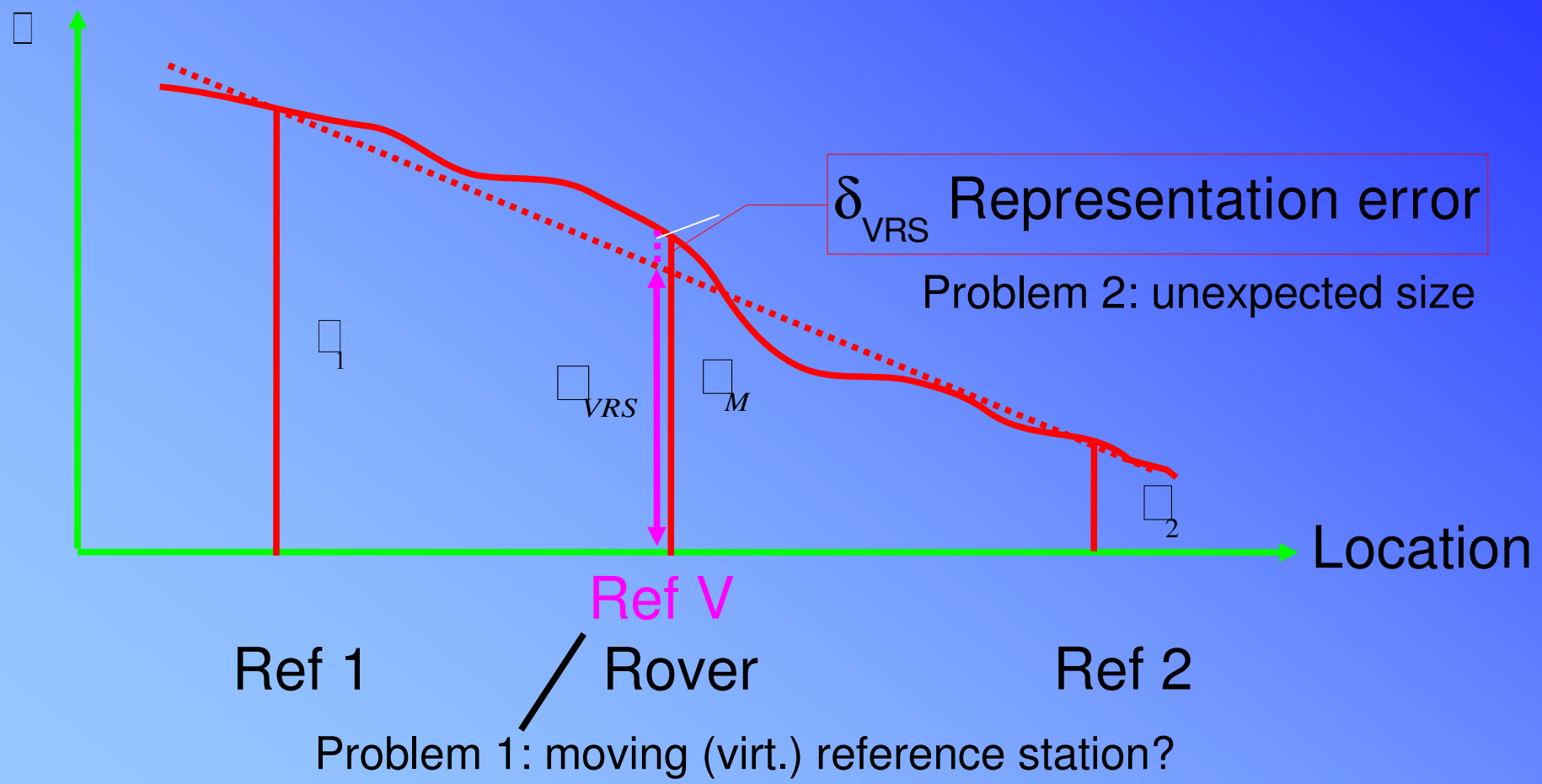
Virtuelle Referenzstation (VRS)

Phase correction



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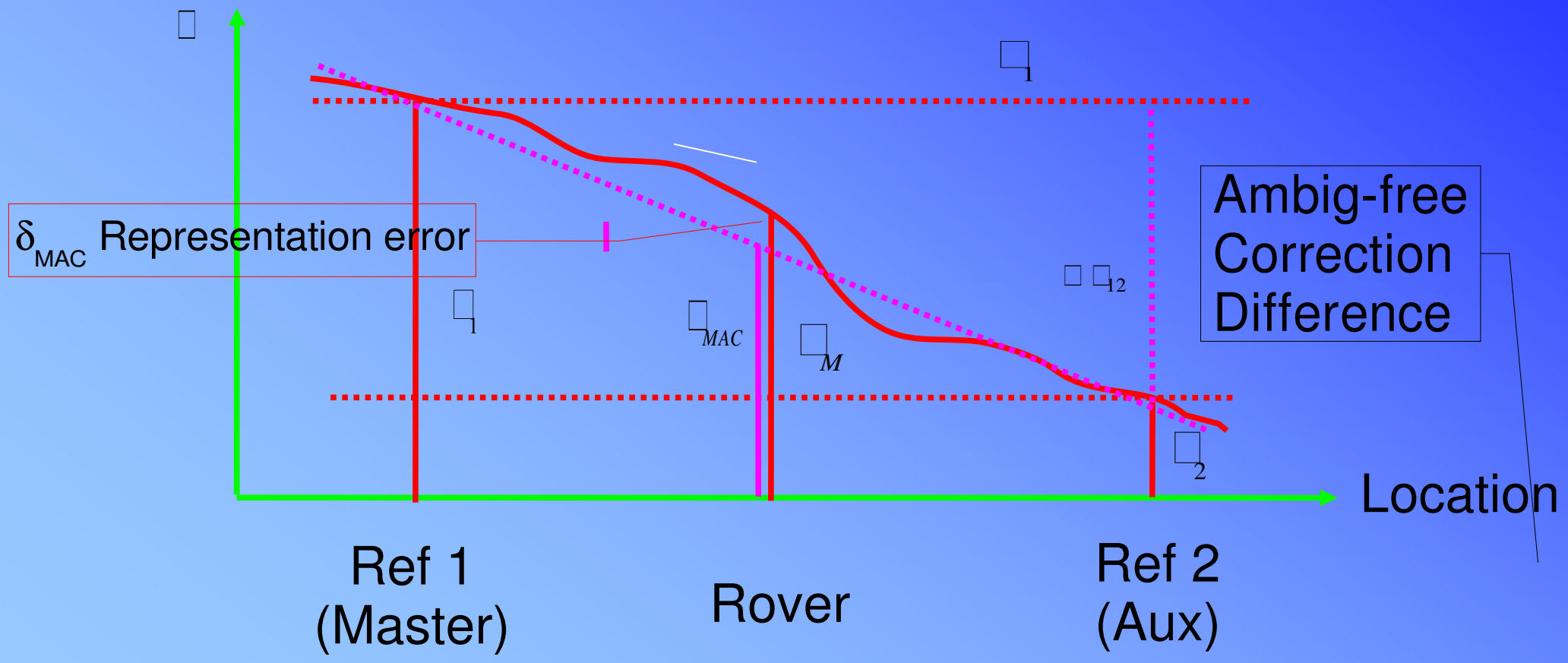
MAC Repräsentation

Master Auxiliary Concept (RTCM3.1)

Phase correction



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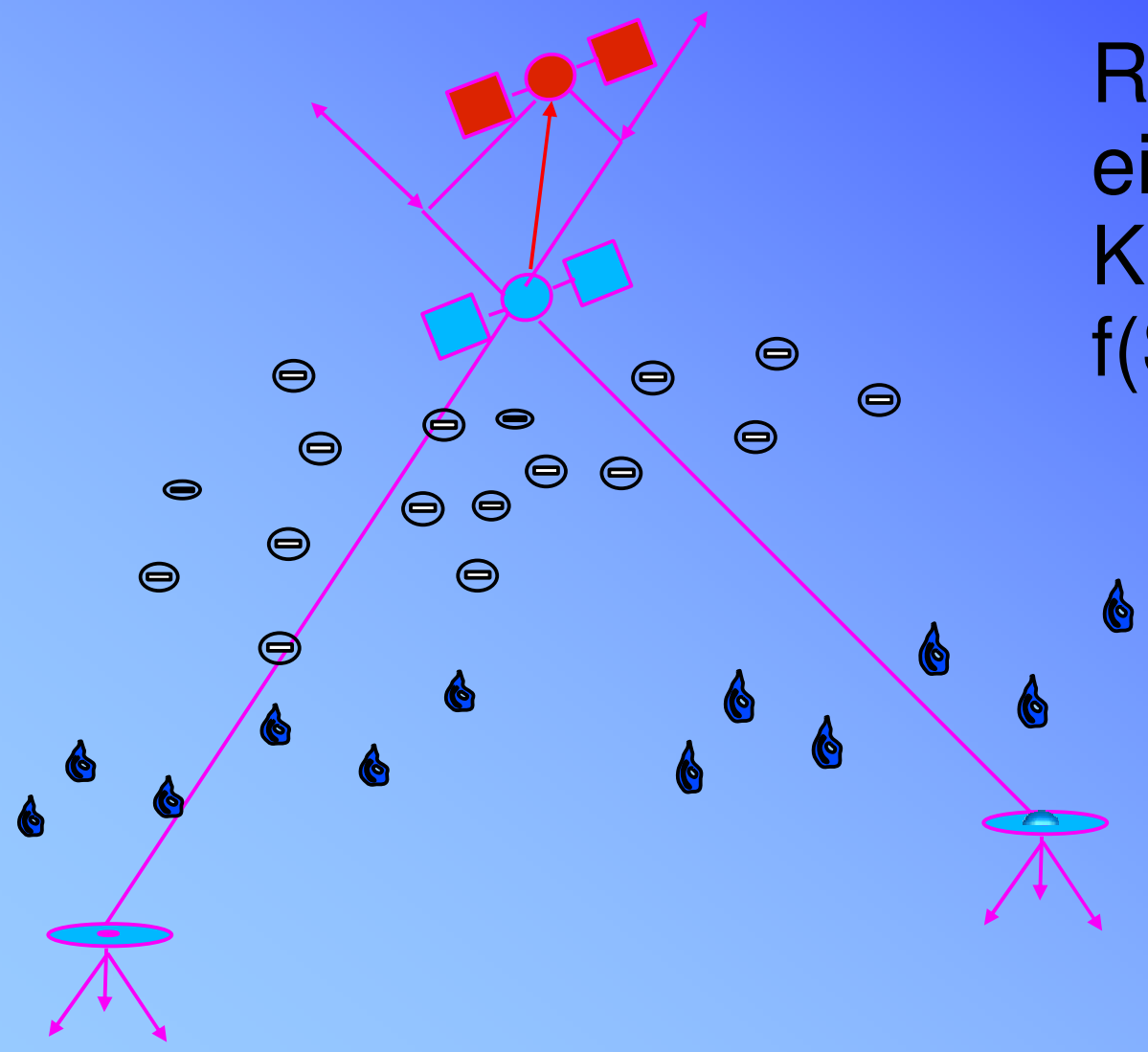
State Space Repräsentation (SSR)



Repräsentation der einzelnen Fehler-Komponenten als f(Satellit), f(Ort)

Loslösung von Referenzstationen

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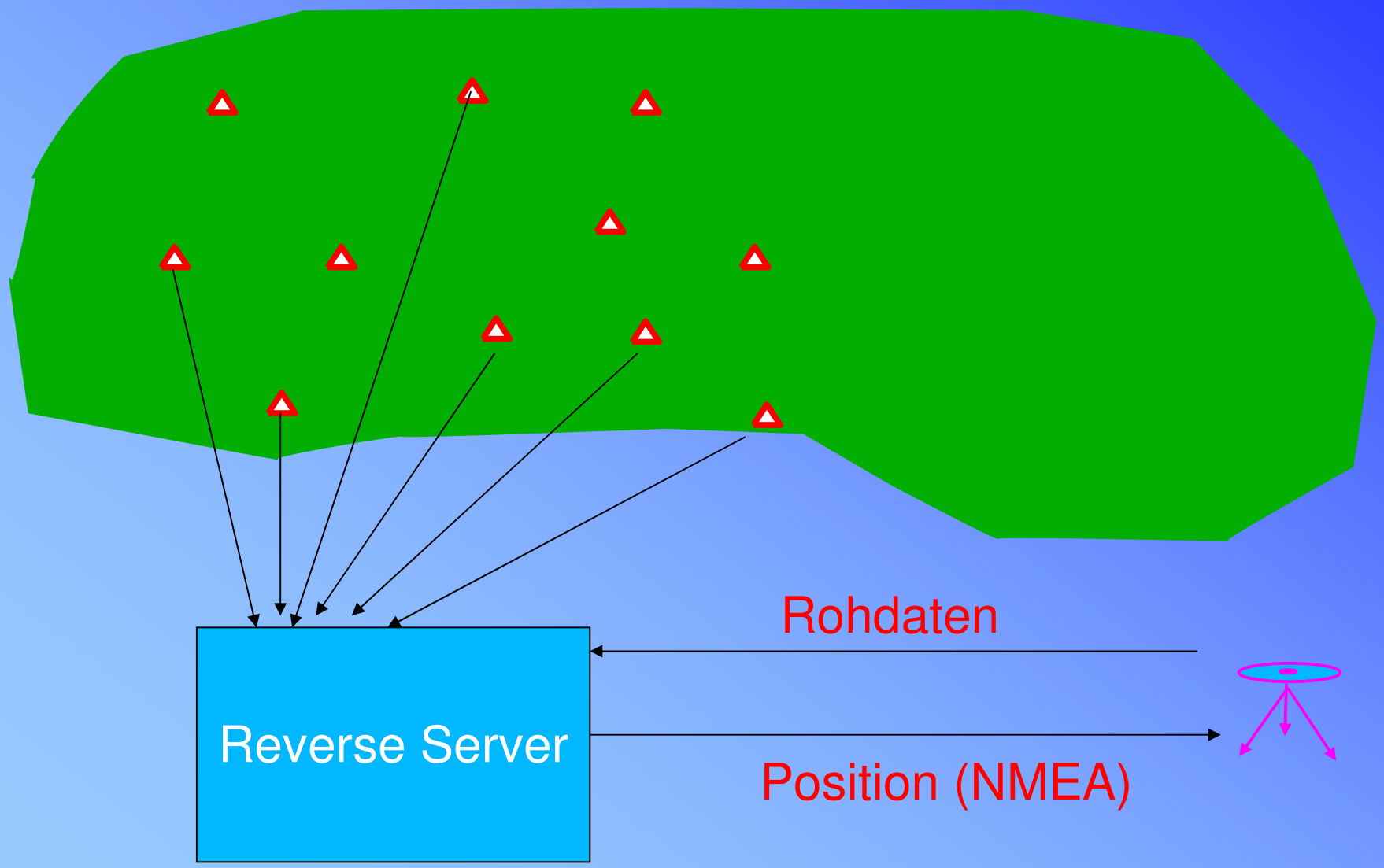
Inverse / Reverse - DGNSS / RTK



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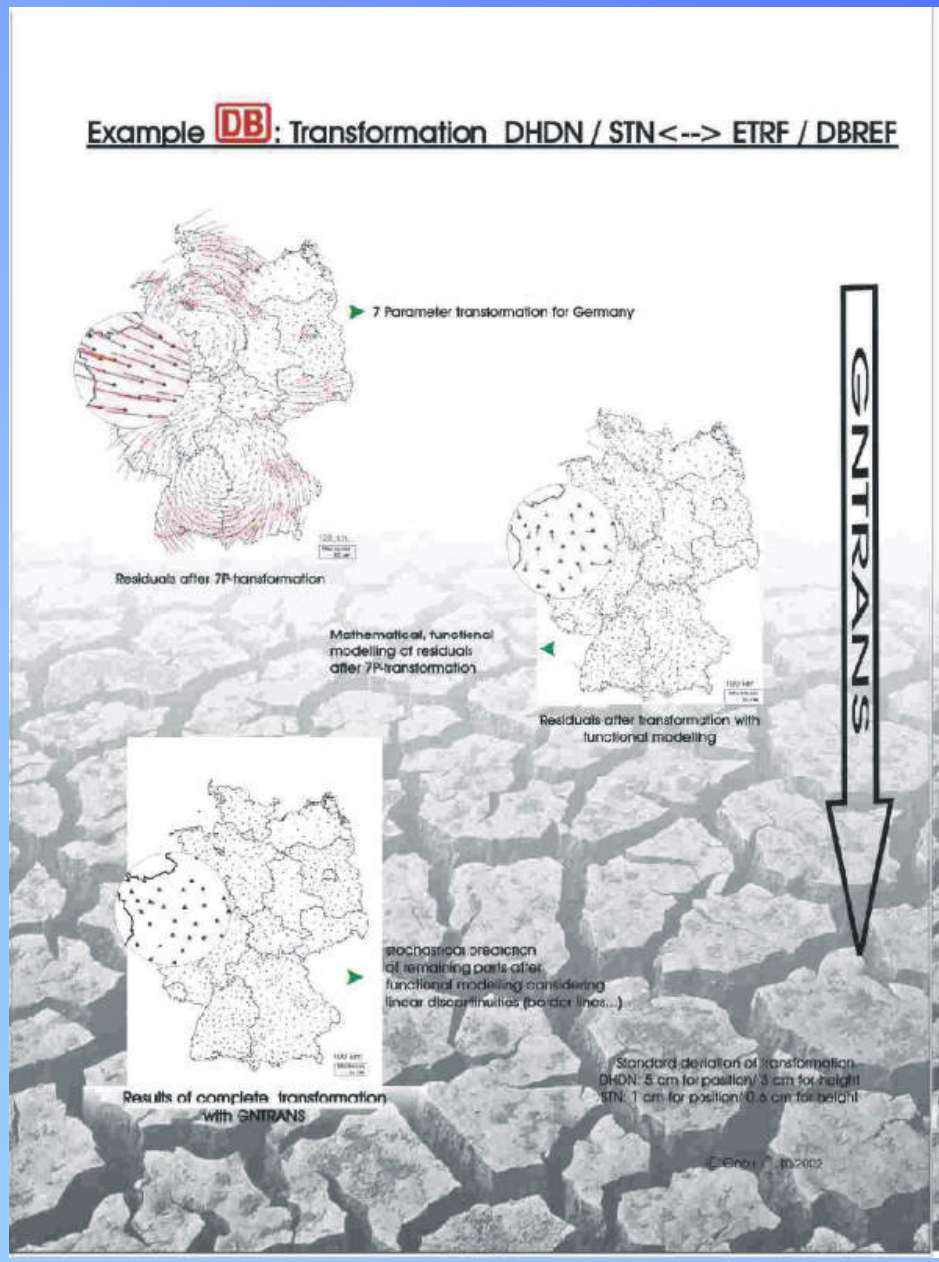
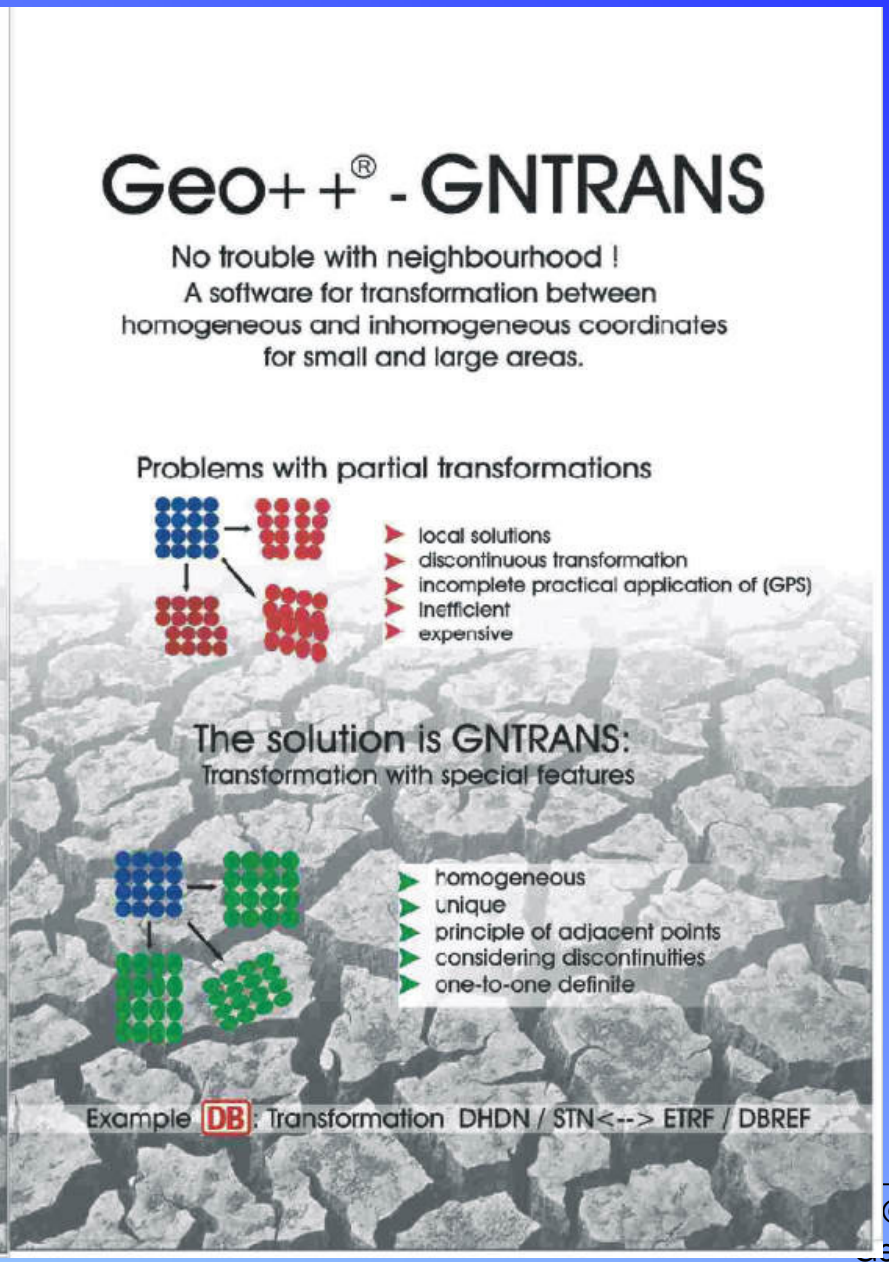
Koordinaten Transformation





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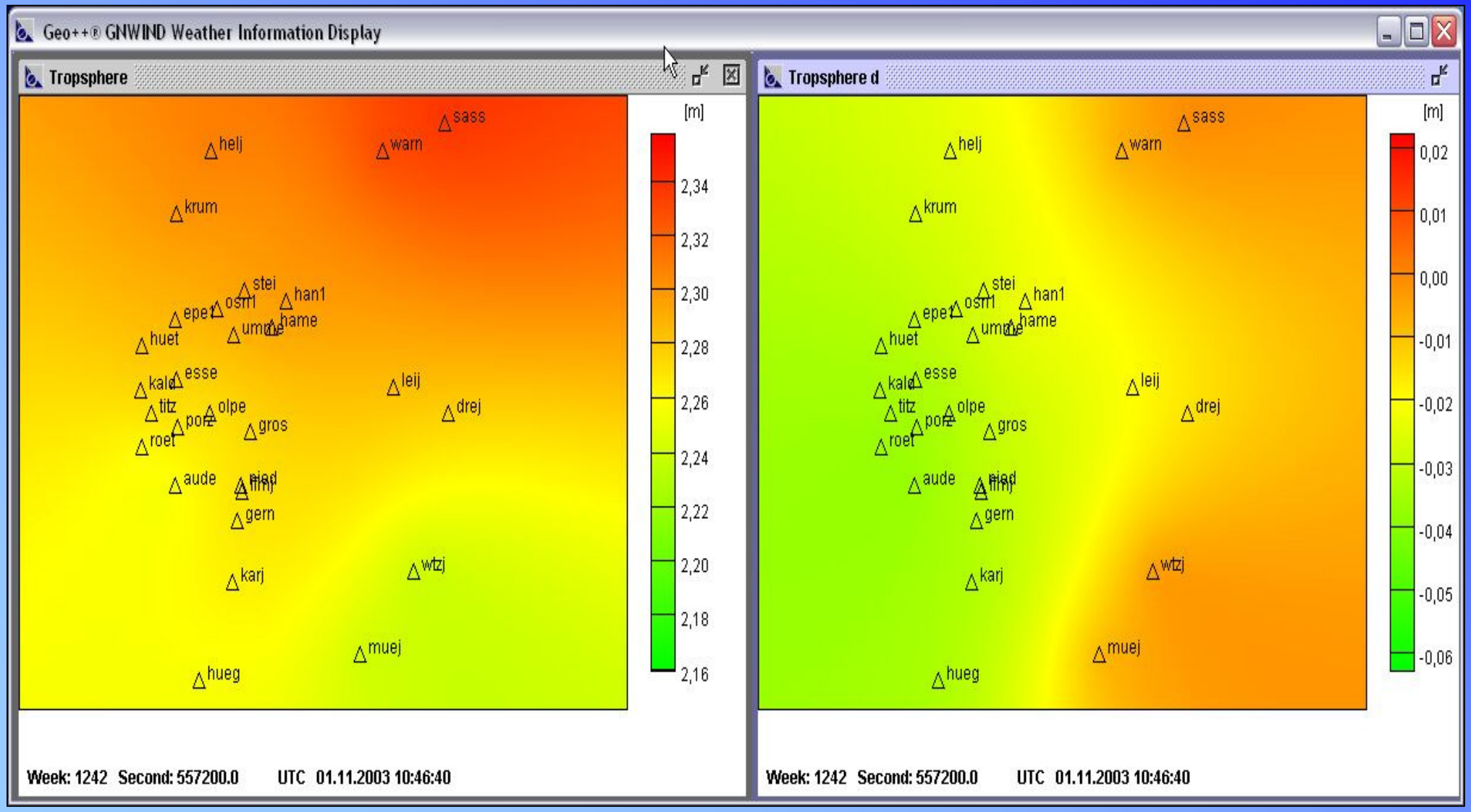
GNSMART Zustandsparameter (ASCII)

~~Troposphere – GNWIND Client~~



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GNSMART-Services

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GNSMART Services

- GPS + GLONASS + (SBAS, Galileo, QZSS, …)
- DGNSS – Dienste
  - RTCM 2, RTCM 3, SSR
- RTK – Dienste
  - RTCM 2.1-2.3, RTCM 3.0, SSR
    - FKP, VRS, PRS, MAC, SSR
- RT Transformation
  - Landessysteme, DBREF,…
- Inverse (Reverse) DGNSS
- Inverse (Reverse) RTK
- Virtuelles RINEX (SSR) – “Postprocessing” (Web-Zugang)
- Kommunikation: GSM, Funk (Broadcast), Internet (NTRIP)

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Geo++® GNSMART

... artist view of Geo++® building in Garbsen

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