POSITIONIERUNG UND LOKALISIERUNG DES ANWENDERS BEI ORTSABHÄNGIGEN DIENSTEN

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THE 21st CENTURY

…the century of the information society

- More and more data require a time and position „stamp“
- ... and create new value-added services and more quality of life

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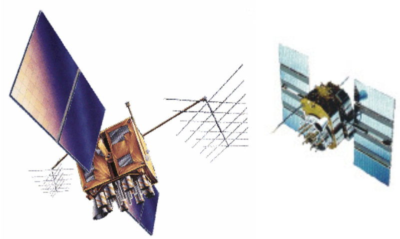
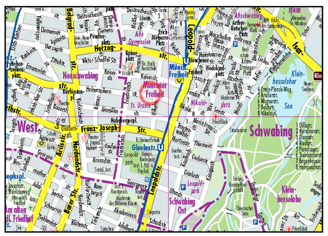
NEW VALUE ADDED SERVICES

New services originate from the combination...



Position and Time

Geoinformation



Mobile Communication

Value added services...

- Agriculture
- Sports & Events
- Transportation & Traffic
- Monitoring
- Security
- Administration
- Spare Time
- Collect charges
- Advertising

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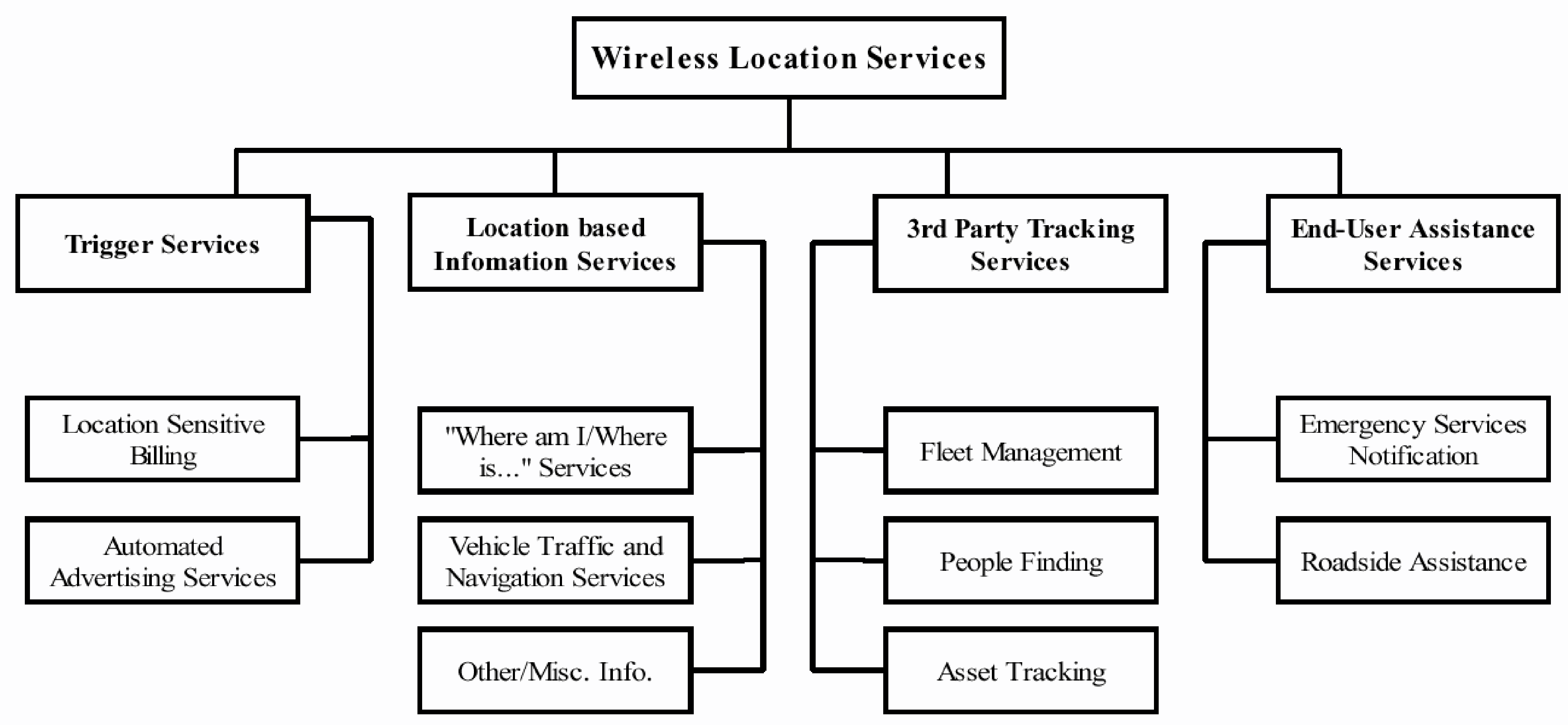
MOBILE COM LOCATION SERVICES



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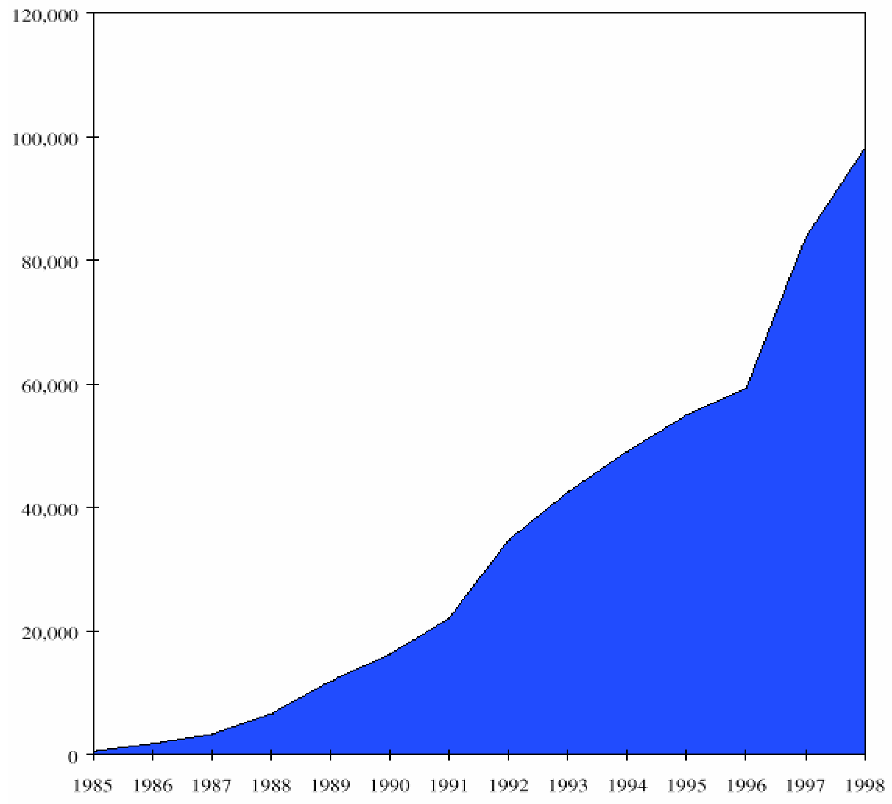
E-911 EMERGENCY CALL IN USA



US FCC Docket No. 94-102
15 Sept. 1999

Network based Locating

100m for 67% of the calls
300m for 95% of the calls

Handset based Locating

50m for 67% of the calls
150m for 95% of the calls

At the latest 01.10.2001

Increase of E-911 emergency calls per day in the USA

Source : Cellular Telecommunications Industry Association

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REGULATORY NETWORK IN EUROPE

- **10 Nov 1999 Review Communication COM(1999)539**
  - Proposals for possible future regulatory measures
    - Location information should be made available to emergency authorities by 1 Jan 2003 (!?)
  - Political discussions started 2000
- **18 Dec 1999 Commission Initiative "eEurope, an Information Society for All"**
  - Full access everywhere to multilingual support, call localisation and fully organised provision of emergency services (112 number)

ÜBERSICHT

- Einteilung der Verfahren
- Netzbasierte Verfahren
  - Zellen-ID und Verfeinerungen
  - GSM Ranging
  - UMTS Ranging
- Handy-basierte Verfahren
  - Satellitennavigation: GPS, GLONASS, GALILEO
- Wireless Assisted GPS
- Quo vadis ?

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METHODS OF POSITIONING

Network-based positioning	Positioning done using signals and hardware only of the telecom system
Handset-based positioning	Positioning done using an independent positioning system (GNSS etc.)
Hybrid positioning	Wireless Assisted GPS
Self positioning	All measurements and calculations re-lated to positioning performed inside MS
Remote positioning	All measurements and calculations re-lated to positioning performed inside network

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NETWORK-BASED POSITIONING 1

- **Zellenortung**
  - Genauigkeit abhängig von Zellgröße (50m … 20 km)
  - Verfeinerung bei mehreren Basisstationen
- **Signalstärke**
  - Vorhandene digitale ortsbezogene Information
  - Ändert sich bei Änderung der Umgebung
- **Verfeinerte Zellenortung**
  - Kombination aus allen netzeigenen Informationen und Signalstärke
  - Genauigkeit unter idealen Verhältnissen bis zu 10-20 m

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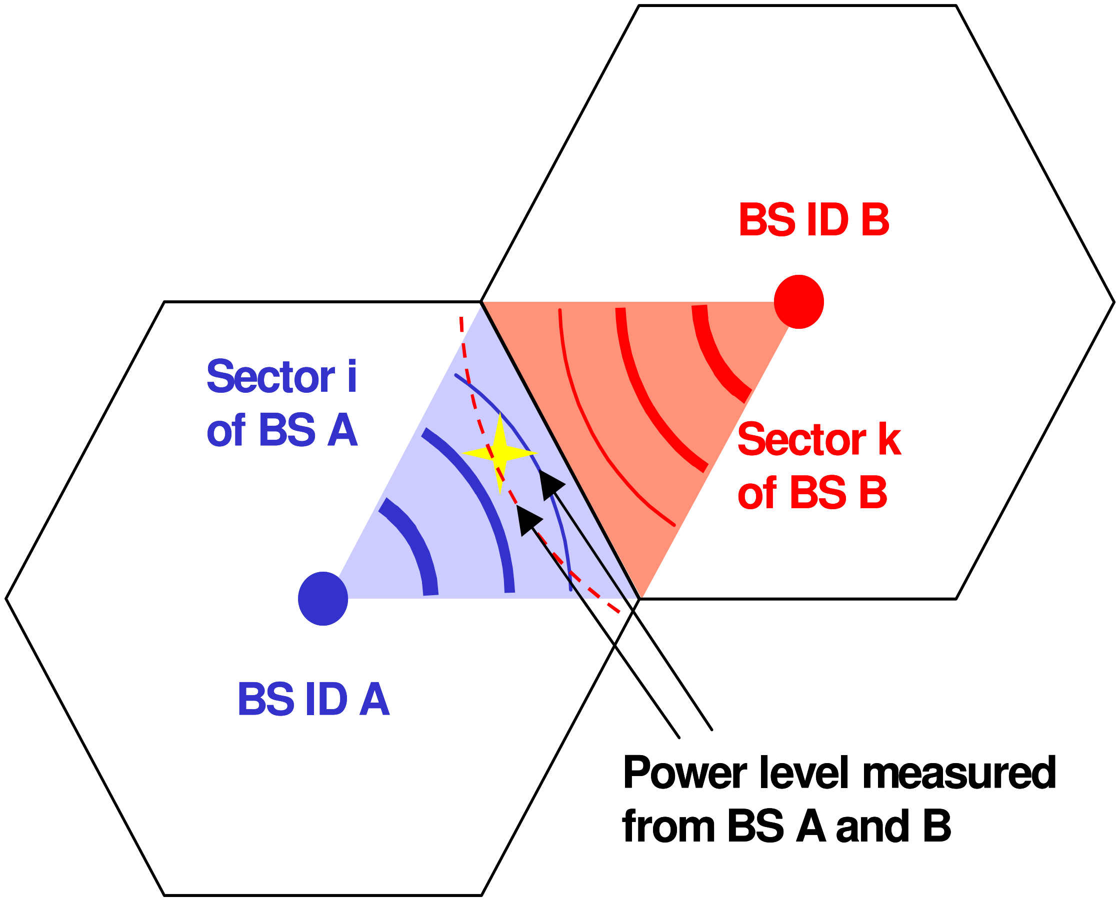
CELL LOCATION & POWER LEVEL DATA



Remarks :

- σ_P ~ cell size

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NETWORK-BASED POSITIONING 2

- **Time of Arrival (ToA)**

  MS at intersection of circles

  Synchronization of BSs and MS required

- **Time Difference of Arrival (TDoA)**

  MS at intersection of hyperbolas

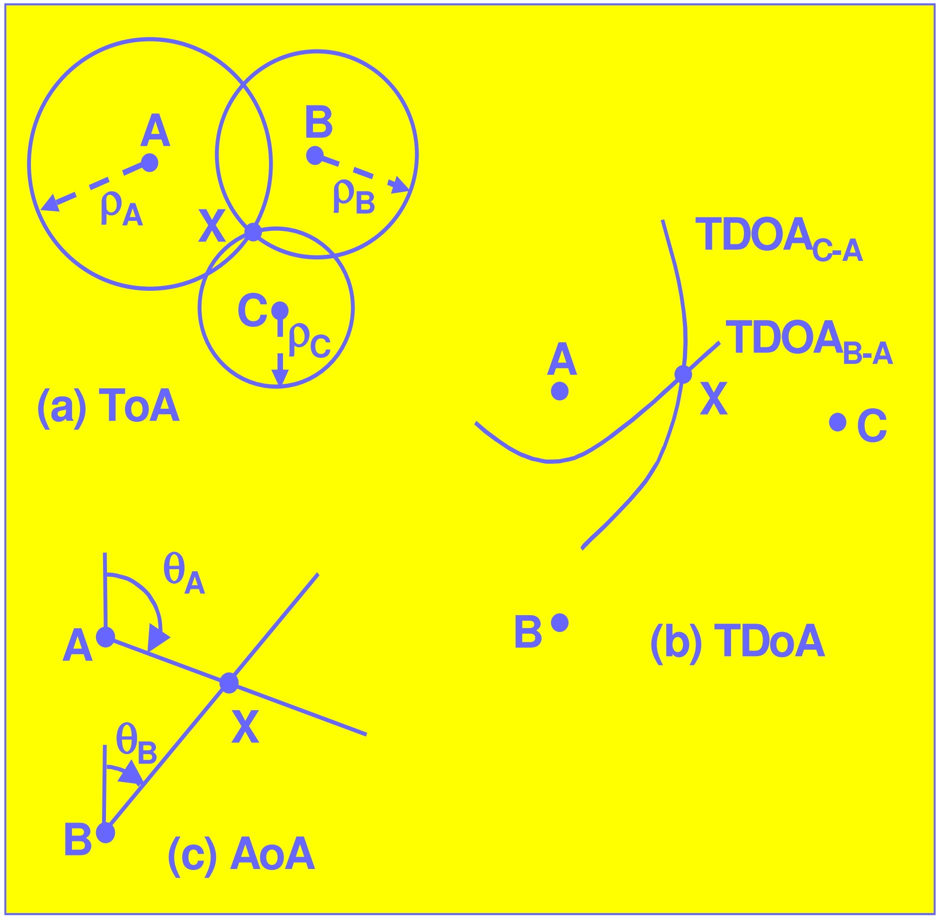
  Synchronization of BSs required

  (Enhanced TDoA)

- **Angle of Arrival (AoA)**

  MS at intersection of directed lines

  No synchronization required



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IMPLEMENTATION IN GSM AND UMTS

	GSM900	UMTS
Multiple Access	FDMA: 200 kHz bandwidth per carrier frequency TDMA: 8 channels per carrier freq.	FDMA: 5 MHz bandwidth per carrier freq. CDMA TDMA: 16 channels
Frequencies	DL: 890-915 MHz UL: 935-960 MHz	DL: 2110-2170 MHz UL: 1920-1980 MHz
Bit rate	271 kbit/s	2 Mchips/s

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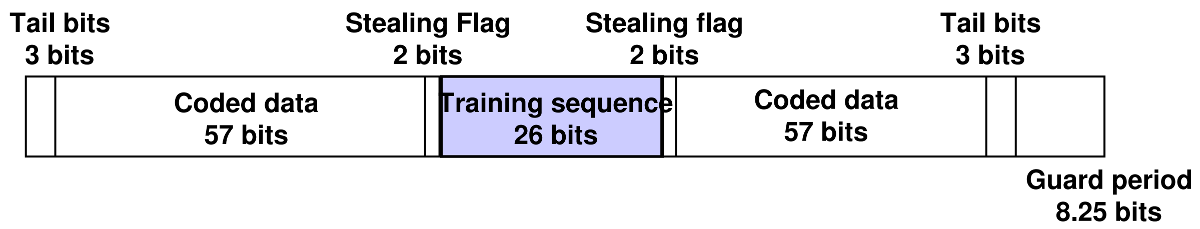
IMPLEMENTATION IN GSM

Correlation method

- 26 training bits in „Normal burst“
- 64 training bits in „Synchronization burst“

Normal burst



Chip length 48/13µs or 1.1km

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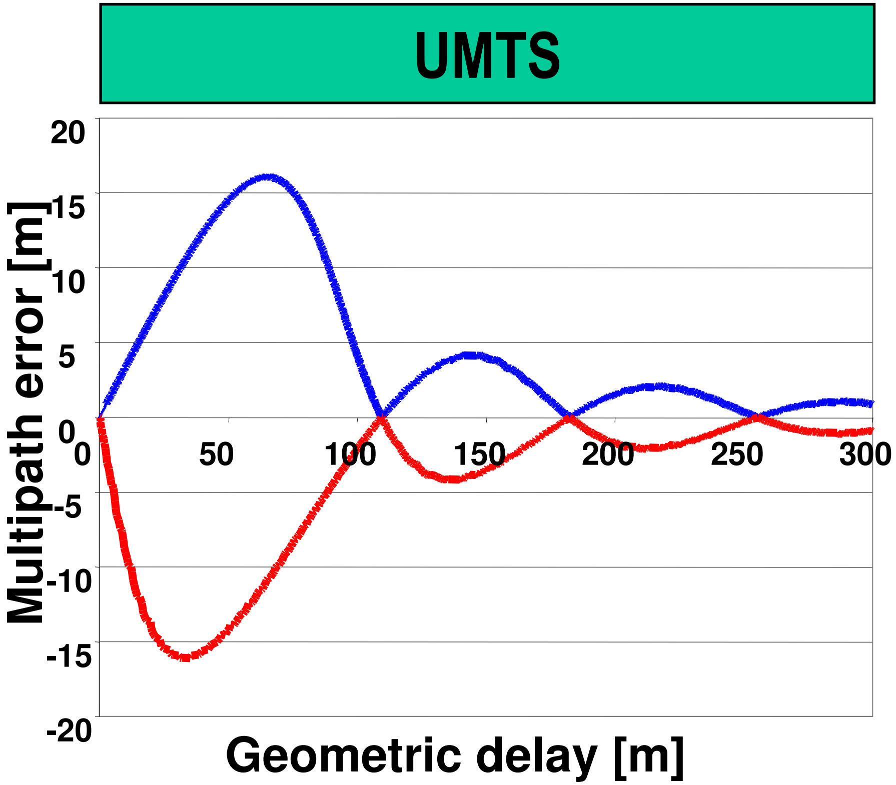
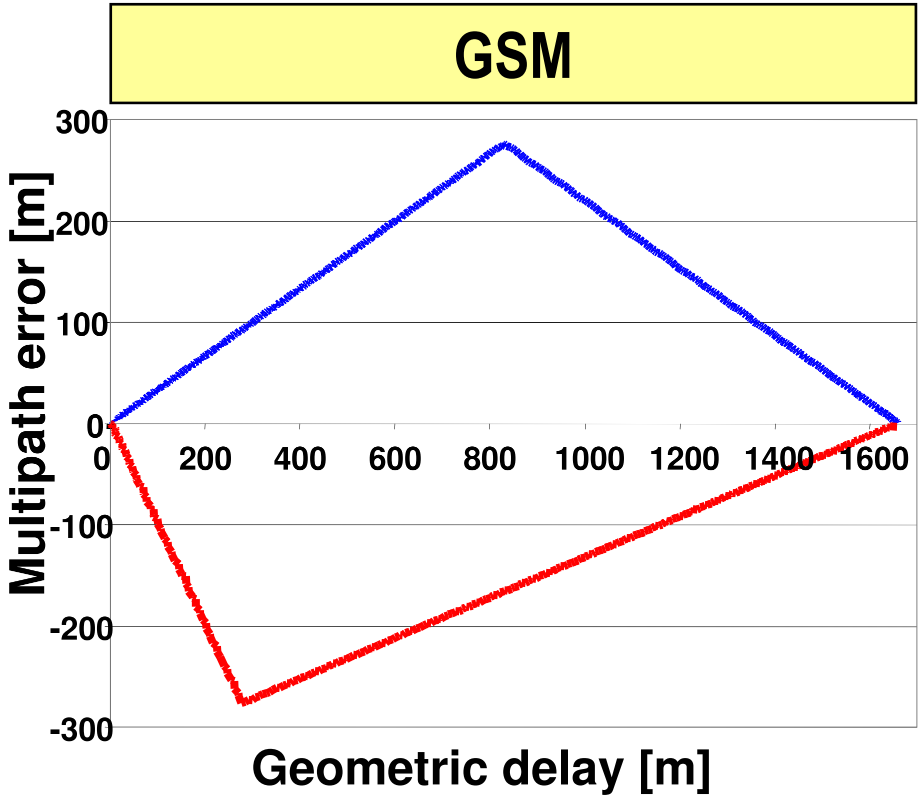
MULTIPATH ERRORS

Multipath error envelopes (multipath errors due to superposition of a direct with an indirect signal, relative attenuation: 0.5)





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RANGING ERROR BUDGET

Error source	GSM	UMTS
Resolution	270 m	18 m
Multipath(*)	0-250 m	0-17 m
Troposphere	0.3-3 m	0.3-3 m
Synchronization of network/handset	3-6 m	3-6 m
Oscillator error	7.5 m	7.5 m
Total error (1 sigma)	**270-380 m**	**19-26 m**

(*) **Not calculated with NLoS**

NLoS causes errors due to multipath corresponding to the geometric delay

Position error = HDOP◆Ranging error◆2 (2dRMS)

Differential techniques can be applied

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HANDSET-BASED POSITIONING

- **Com & nav sensor (GPS) operate independently**
  - No integration
  - Such handsets (including GPS) are already available
- **Wireless Assisted GPS**
  - Synergies are used between com & nav
  - First implementations and experiences, also indoors
- **Integration of handset and GNSS functions**
  - First investigations

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WIRELESS ASSISTED GNSS

- **Additional data for the GPS receiver through cellular network**
  - Purpose: Fast acquisition of satellites
  - Satellite ephemeris, more data for signal tracking
  - Time synchronization (GPS code offset)
  - Position determination using Doppler, cell-id constraints, DGPS corrections)
- **Advantages**
  - Reduced time for acquisition, single „shot“ measurements
  - Higher sensitivity for reception of „weak“ satellite signals
  - Reduced power consumption of GPS receiver / mobile set

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SIMULATIONS

- UMTS signal structure built-in into institute´s SatNav end-to-end S/W simulator
- Two test areas
  - Stuttgart downtown: High density of BSs, micro-cells
  - Oedekoven (suburb of Bonn): Rural BS structure
- Calculations (only horiz pos possible)
  - Number of “visible” (receivable) base stations
  - Geometry factors
  - Densification of MobCom network:
  - Number of necessary BSs for area-wide positioning
  - GPS vs. network-based

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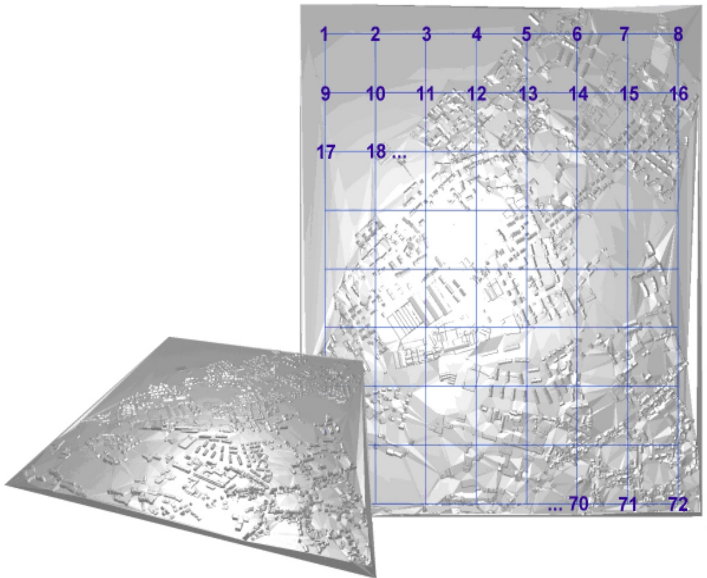
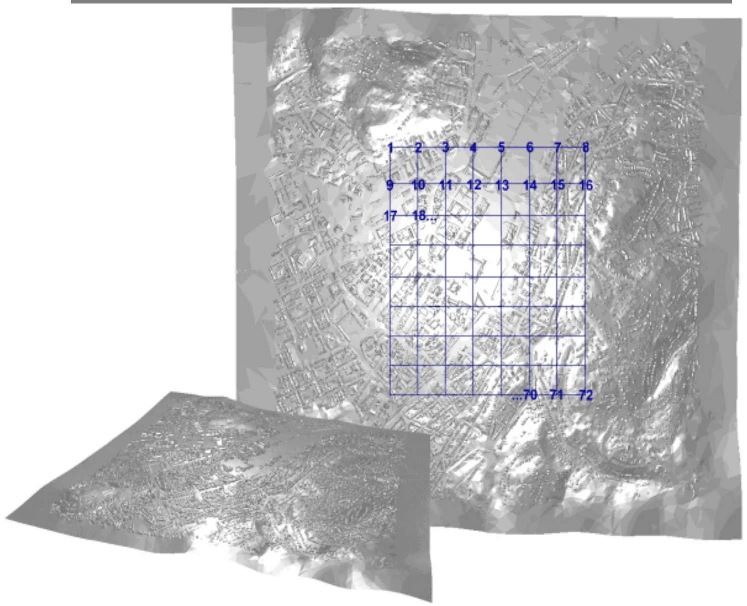
TEST AREAS

OEDEKOVEN (NEAR BONN)
1.5 km E-W, 1.8 km N-S
31 Base stations

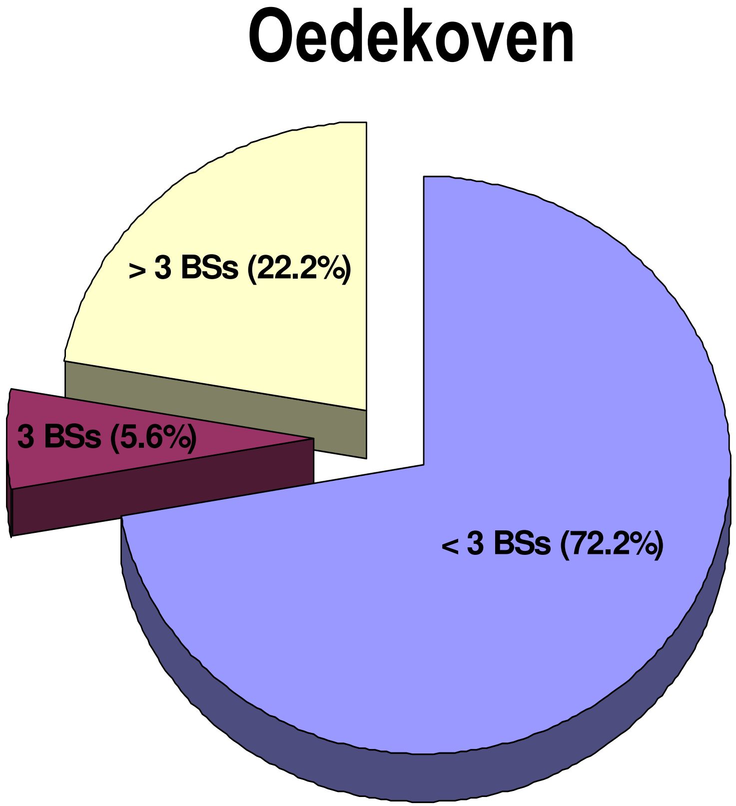
DOWNTOWN STUTTGART
3.0 km E-W, 3.0 km N-S
178 Base stations

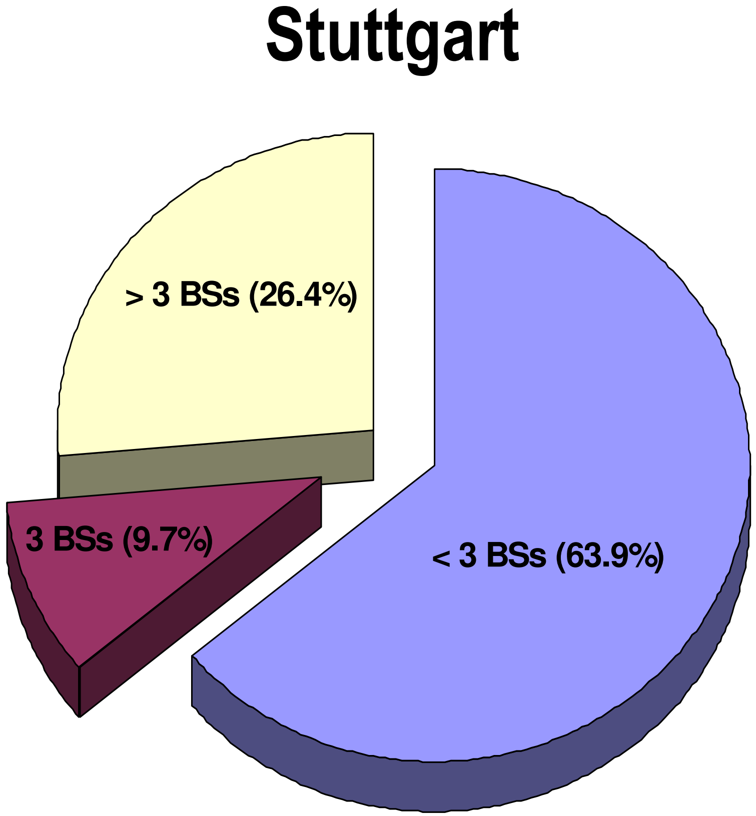




Grid: 200m x 200m, 1.5m above bottom

NUMBER OF RECEIVED BSs





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ESTIMATES OF REQUIRED INFRASTRUCTURE

- Area-wide UMTS positioning in D < 50m
  - Increasing the **NUMBER of BSs with factor 2-3** due to geometry
  - 40 000 BSs x $ 50 000… $ 90 000 = **$ 2 … 3.6 billion**
- Synchronization of BSs (with higher accuracy) necessary
  - DCF77 and Quartz not sufficient (10^{-7}s) > Rubidium or GPS
  - 20 000 BSs x $ 5 000 = **$ 100 million**
- Telecom network with Location Measurement Units (LMU)
  - Per 3-5 cells 1 LMU; approx. $ 7 000 … $ 10 000; 20 000 cells in Germany
  - Investment costs for LMUs only D: **$ 50 ... 70 million**
- Total costs **2D positioning 100m (2drms) in D: $ 2.1 … 3.8 billion**
- For comparison: USA >$ 5 billion

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INTEGRATION HANDSET & GPS RCVR

- **Possible tightly integration**
  (1) Reference oscillator (different quality, change of frequency plans)
  (2) RF sub-system (Multiplexer, Filter - GPS Interference to mobile Phone itself)
  (3) Correlator structure / CDMA tracking loops
  (4) Micro-processor H/W and interfaces
- **First studies, up till now no (known) developments**
- **Power consumption GPS and lifetime of batteries**
  - Principle „single shot“ GPS measurements supplemented by data provided by the cellular phone network (Wireless Assisted GPS)

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QUO VADIS ? 1

- **Cell-ID positioning will stay for more years**
  - Refinements are still possible
  - No change and (large) investments in telecom nets necessary
  - Positioning in most cases for LBS sufficient
  - Drawbacks
    - No height information
    - Low accuracy in countryside – mostly not sufficient
- **CDMA Ranging in GSM makes no sense**
- **CDMA Ranging in UMTS requires large infrastructure and investments**
  - Accuracy in ideal cases 10 … 20 m
  - Drawbacks
    - No height information
    - Low accuracy in countryside

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QUO VADIS ? 2

- **Trend: GPS (GNSS) in mobile phone**
  - Wireless assisted GPS as a new service
  - Indoor positioning possible
  - Advantages
    - 3D-positioning
    - High accuracy possible up to meter accuracy
    - Globally in all areas available
- **Further developments 2008**
  - European Satellite Navigation System GALILEO

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