Berner Fachhochschule (BFH)

„Innovation in der Praxis“

14. August 2009

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RFIDnet Bern GmbH

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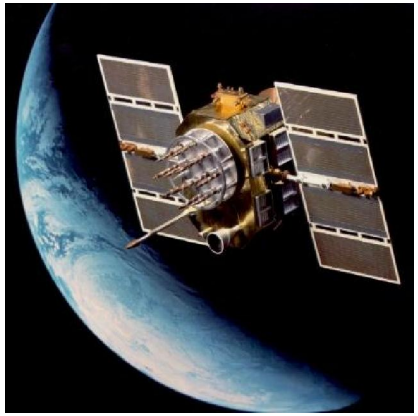
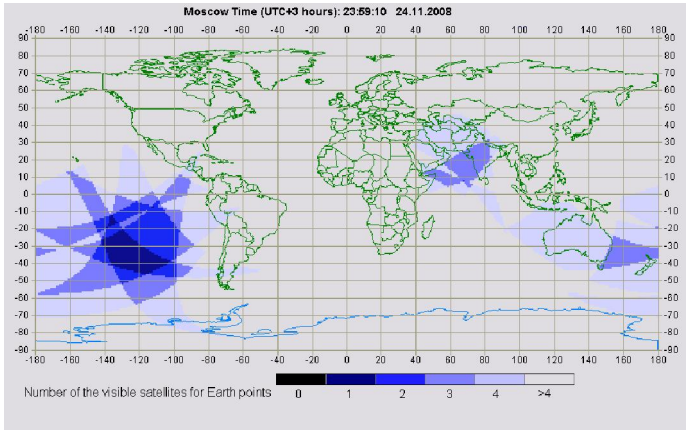
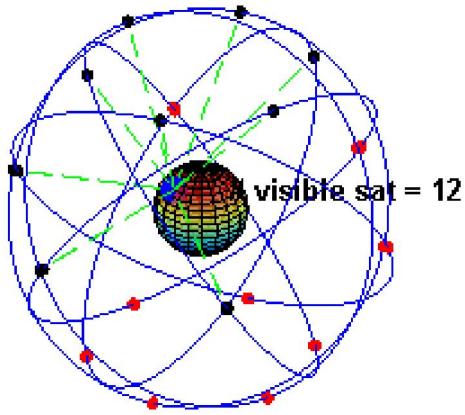
Indoor and Outdoor Positioning Systems – the limits of today's RFID positioning technologies

David C. Gürlet, CEO RFIDnet Bern Ltd.

A look at today's GPS (outdoor) and RTLS (indoor) systems; followed by a review of the latest technologies (active RFID, RFID via WLAN, UWB, e-INS).







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Agenda

1. RFIDnet Bern GmbH
2. Today's RTLS-World
    1. Acronyms / Basics / Technologies
    2. Position Accuracy
    3. Outdoor & Global - RTLS (NAVSTAR=GPS, GLONAS, GALILEO)
    4. General RFID Technology & Freqency Overview
    5. Indoor Positioning Techniques
    6. RTLS: Active RFID / WLAN-Based / UWB / e-INS
3. Tomorrow's RTLS-World (combined)
4. Q & A's

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RFIDnet Bern GmbH

Swiss RFID Competence Network

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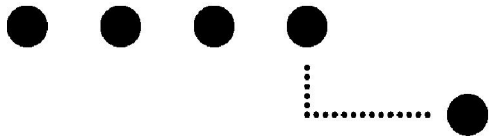

Berner Fachhochschule
Technik und Informatik

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1.1 RFIDnet Portfolio

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1.2 Consulting

- Swiss Entrypoint for all RFID-Questions
- Neutral Consulting for all RFID-Markets & Applications
- Manufacturer neutral 2nd Opinion Analysis & Mediations
- Feasibility Studies & Proof-of-Concepts
- NEW: Workshop **„are you ready for RFID?“** (1 day)

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1.3 Events & Trainings 2009

RFID-Events

- 3 Late Afternoon Events with RFID-Sitevisits
  17.4.09 – EM Marin,
  12.6.09 Manor
  6.11.09 ELSA-EMMI-MIGROS
- 1 RFID Competence Day = Meet-The-Expert
  à Friday, 11.9.2009 @ Inselspital Bern mit Medical-Cluster
- Presentations @ Events
  à ETH-Serec, BFH Biel, BFH Bern, WFB, etc.

RFID-Trainings

- RFID: Basics, Applications, Economics
  à 2 days Training
- 1 day WorkShop **„are you ready for RFID?“** anytime@customer

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1.4 Memberships / Links / Partner & Supporter

- Berner Fachhochschule TI www.ti.bfh.ch
- Member of SwissTnet RFID-Sektion 51 www.swissT.net
- Member of AIM Deutschland / Schweiz http://www.aim-d.de/
- Links to other international RFID-Organisations (Fraunhofer, EU-Research, RFID-im-Blick, AIM Global, etc.)

Berner Fachhochschule
Technik und Informatik

tcbe.ch
ICT Cluster Bern, Switzerland

SOHARD AG

EHAG
ELECTRONIC HARDWARE AG

noser

IDENTEC SOLUTIONS

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2. Today's RTLS-World

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2.0 Acronyms & Terminology

- RTLS : Real-Time Location System
- RFID : Radio Frequency Identification
- IT : Information technology
- LF : Low frequency
- HF : High frequency
- RF : Radio frequency
- IR : Infra red
- WLAN : Wireless LAN
- LAN : Local area network
- UWB : Ultra wideband
- DECT : Digital Enhanced Cordless Telecommunications
- EMC : Electromagnetical compatibility

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2.0 Acronyms – Terminology - Definitions

- Tag : Electronic chip with unique ID (and data)
- Reader : Electronic device to read/write tags
- Antenna : Part of reader, enabling comm. with tags
- Passive : RFID tag technology without batteries
- Active : RFID tag technology with batteries
- Semi-active : RFID tag with dual power solution
- Semi-passive : Same as Semi-active
- RFID-Chip : RFID Chip + RFID Antenna = RFID tag
- Badge, inlay, keyfob, card, etc : RFID chip + antenna + « container »

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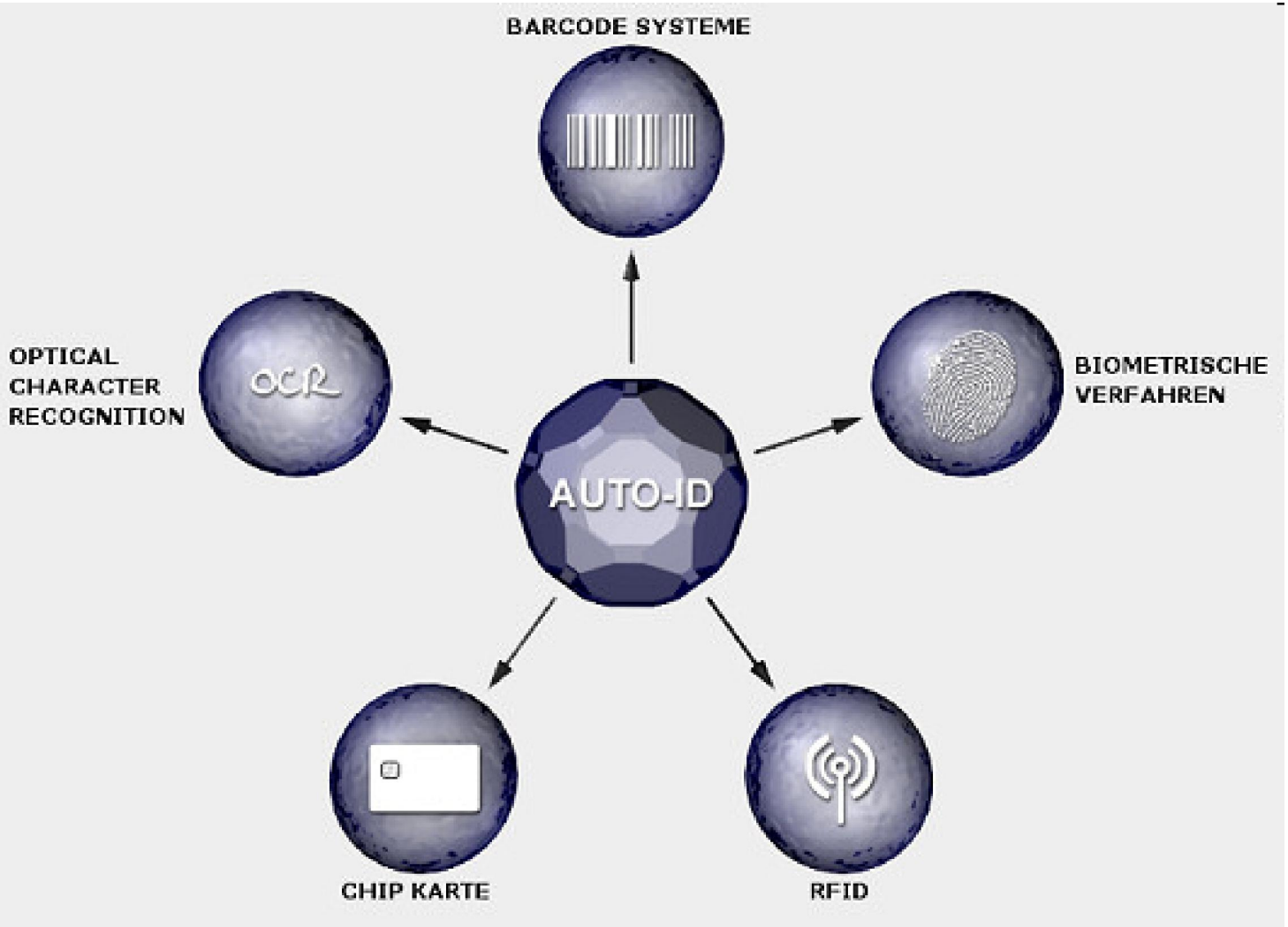
Definition of Auto-ID



*) missing : DNA

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Definition of RFID

- **Wikipedia:** Radio-frequency identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders.
- **RFID Journal:** Radio frequency identification (RFID) is a generic term that is used to describe a system that transmits the identity (in the form of a unique serial number) of an object or person wirelessly, using radio waves

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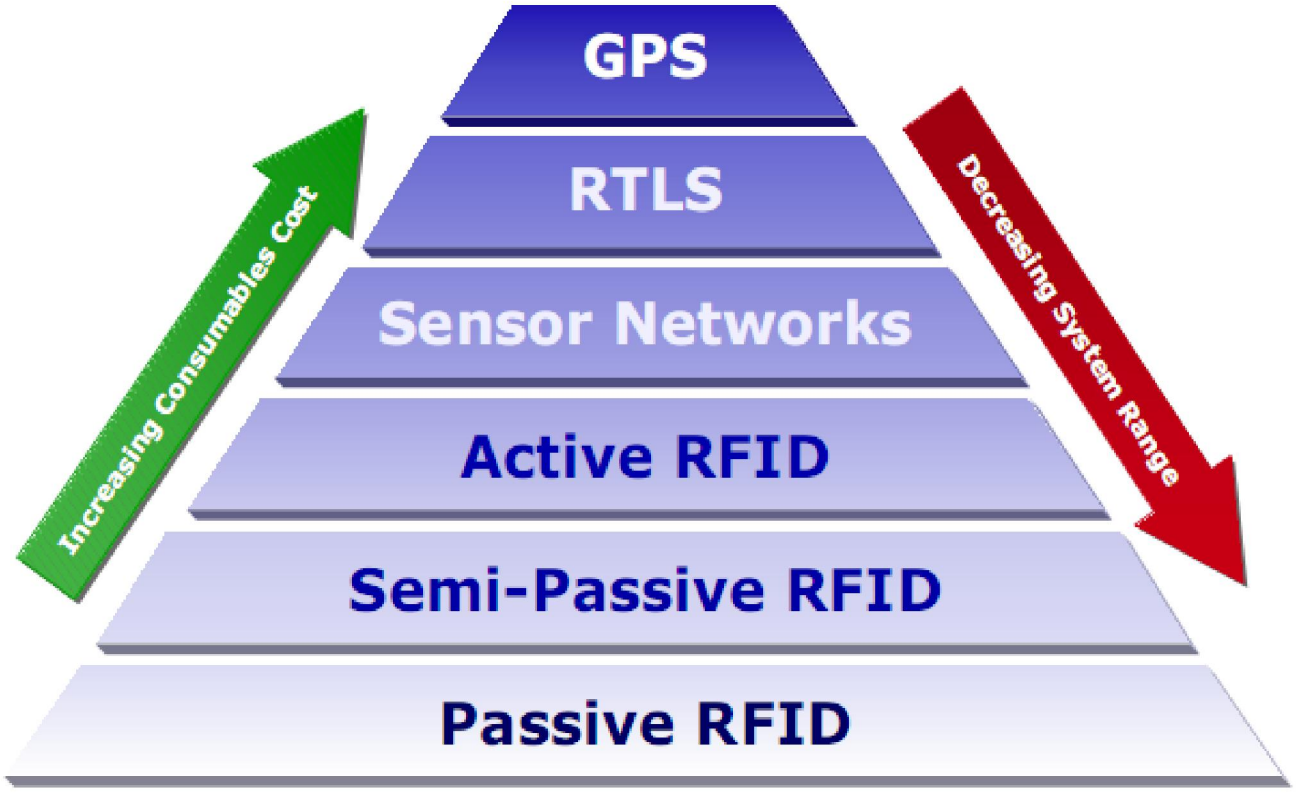
2.1 Basics - RTLS & RFID or what it is !



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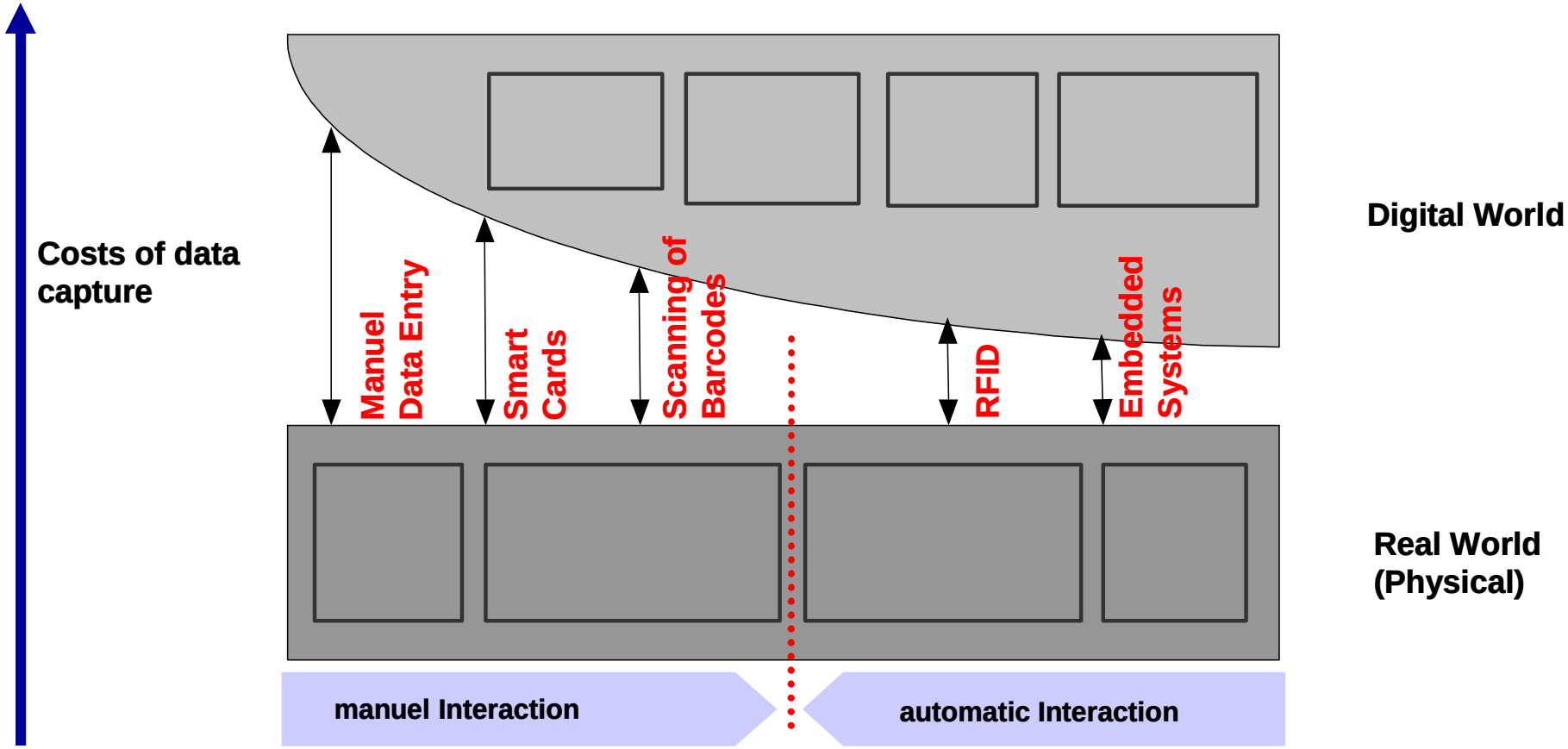
2.1 Basics - RTLS & RFID or what it is !



Source: E. Fleisch / M. Dierkes

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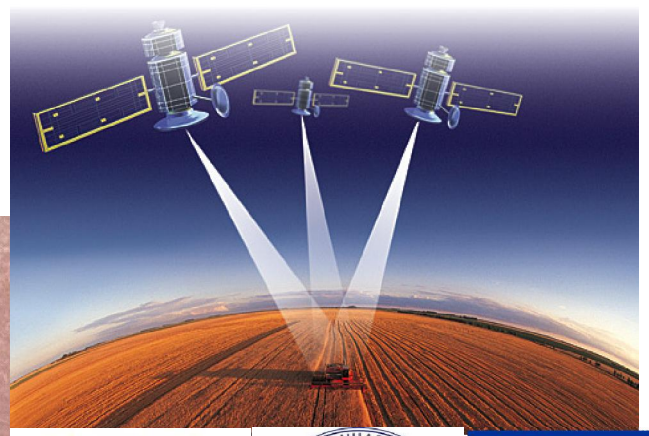
2.1 Basics - RTLS & RFID or what it is NOT!

« RFID is that 2-cents small spy-chip that we can't see, that holds 1'000 encyclopedias of data and that can be tracked by satellite with a precision of a few mm»

(Citation from customer discussion)



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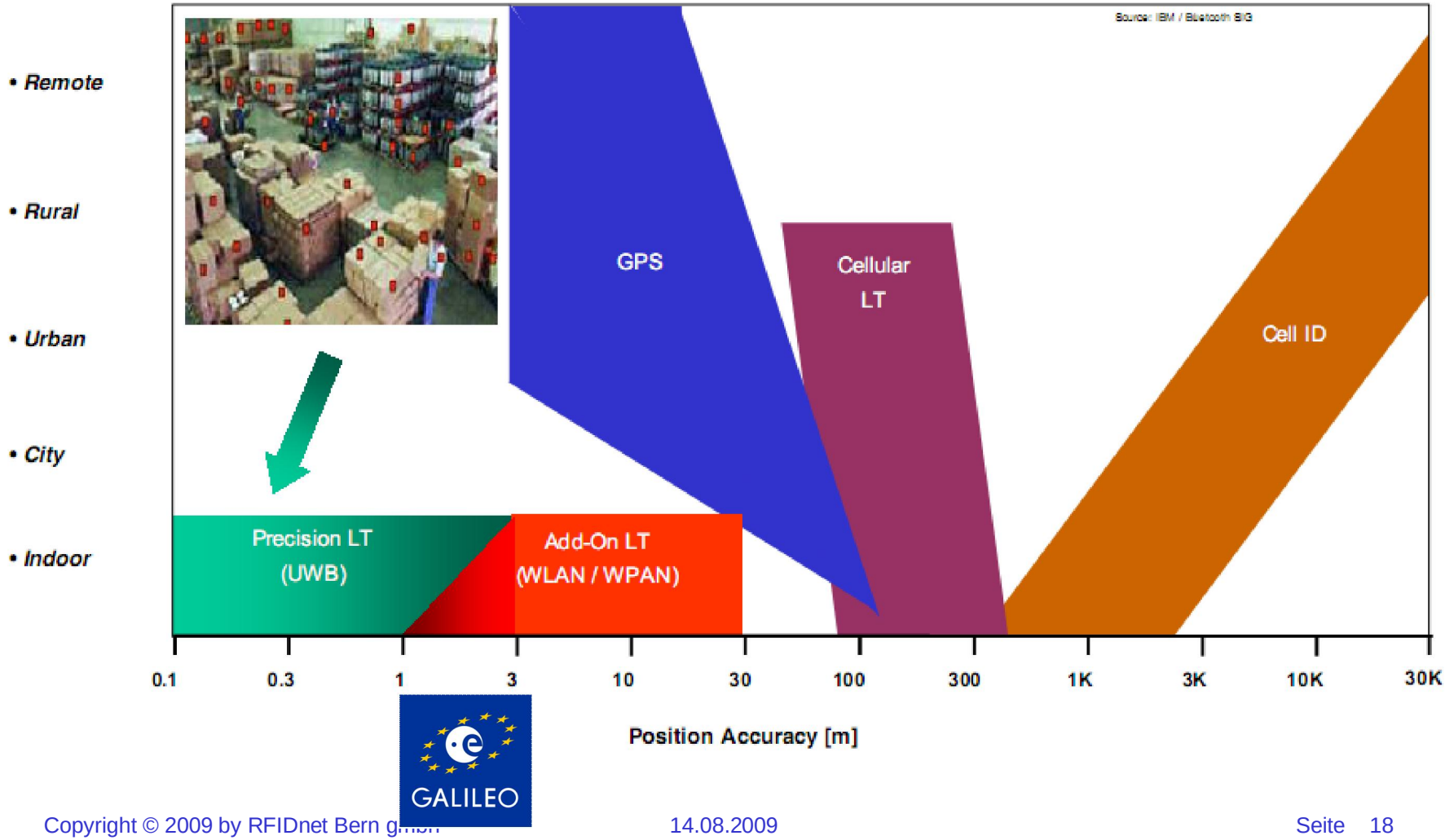
2.2 Position Accuracy RTLS (in- & outdoor)



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2.3 Outdoor & Global

COMPASS – covering China
INRSS – covering India
QZSS – covering Japan

operational

„Navigational Satellite Timing and Ranging - Global Positioning System“ à NAVSTAR-GPS operational since 17.7.95 operated by US-DoD
Acc. civil=15m, D-GPS = 0.01 – 5m (differential GPS)

GLONASS **(russ. ГЛОНАСС – Глобальная Навигационная Спутниковая Система, translated global navigation satellite system), operational since 1996 & again 2008, Reference for Galileo**

GALILEO GPS for Europe, compatible NAVSTAR-GPS III (2010=
Costs today = 1.5 Mia Euros + 3.4 Mia Euros (Budget à 2013),
1st Satellite à GIOVE-A1 (Galileo In-Orbit Validation Element)
started 28th of December 2005/5:19 UTC from Baikonur (Kasachstan)
operational 2013, tested with GLONAS, Acc. Civil ~ 1m

Galileo Galilei (15 February 1564 – 8 January 1642)

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2.3.1 Wer hat‘s erfunden?

- Die Grundidee, mittels Satelliten ein Navigationssystem aufzubauen, gab es bereits vor dem Zweiten Weltkrieg: Am 11. Mai 1939 meldete der deutsche Ingenieur Karl Hans Janke in Berlin ein Patent für einen „Standortanzeiger, insbesondere für Luftfahrzeuge“ an, welches am 11. November 1943 erteilt wurde. Im Patent geht er von zwei entfernten Körpern (Satelliten) aus, die permanent elektromagnetische Signale senden. Die Signale können empfangen werden und als Vektor auf einem Bildschirm angezeigt werden. Legt man nun eine Karte über den Bildschirm, könne man sogar die Herkunft und Richtung eines Objektes bestimmen. Karl Hans Janke wurde in der DDR wegen „wahnhaftem Erfinden“ eingesperrt und verstarb 1988 in der Psychiatrie Hubertusburg.[4]

See today‘s Satellites here ….

http://science.nasa.gov/RealTime/JTrack/3D/JTrack3D.html

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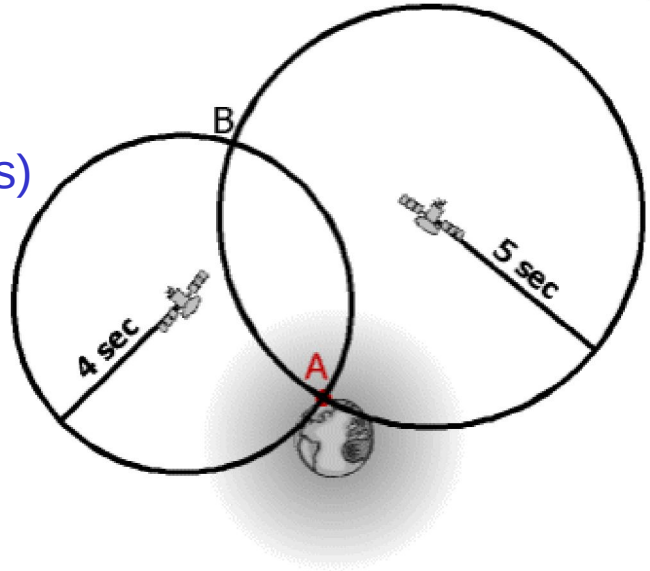
2.3.2 How does it work ? http://www.kowoma.de/gps/index.htm

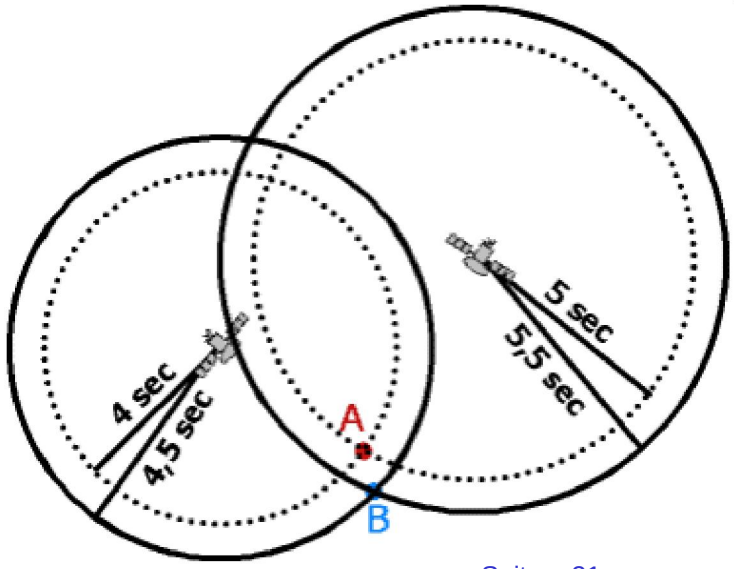
1. we need at least 21 satellites (usually 24-30) ..
2. on an 20.2 km Orbit, 55 deg. Inclination with very accurate time (3 x 10 power-8 sec. = 10meters)

3. we see 3 satellites @ same time for 2D position fix
4. we receive first satellite message „I am Sat X, was on Position Y at Time Z“ …
5. Second Satellite sends it‘s message
6. Third satellite sends it‘s message ….
7. GPS-Receiver calculates Position on earth with „time-of-arrival minus time-sent for signal“ (TOA) and Trilateration

8. For 3D position fix, we need to see at least 4 satellites @ same time

9. Speed on earth is measured by differential calc. of multiple positioning infos
10. Accuracy > 15 meters, with D-GPS < 1 Meter





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2.4.0 General RFID - Technology & Frequency Overview

	NF	HF	UHF		Mikrowelle
RFID Frequenz	100 - 135 kHz	13,56 MHz	868 MHz		2,45 GHz
Energiever-sorgung	induktiv	induktiv	elektromagnetisch (Backscatter)	elektromagnetisch (Backscatter)	elektromagnetisch/ autonom
Transponder	passiv	passiv	passiv	semi-aktiv	aktiv
Untergrund des Transponder (kein Metall)	kein Einfluss	geringer Einfluss	geringer Einfluss	kein Einfluss	kein Einfluss
Untergrund des Transponder Metall	bedingte Lesbarkeit	keine Lesbarkeit; (Ausnahme Speziallabel)	geringe Lesbarkeit;	sehr gute Lesbarkeit	sehr gute Lesbarkeit
Wasser/ Feuchtigkeit	kein Einfluss	geringer Einfluss	starker / sehr starker Einfluss	sehr geringer /kein Einfluss	sehr geringer /kein Einfluss
Pulk-Fähigkeit	kaum implementiert	~ 50 - 200 Tag IDs / s	~ 50 Tag IDs / s	~ 200 Tag IDs / s	~ 200 Tag IDs / s
Lesereichweite (Tag-Größe: Scheckkarte)	0 - 100 cm	0 - 100 cm	US: 0 – 400 cm EU: 0 - 250 cm	bis ~ 10 Meter	> 10 Meter
Datentransfer-Rate	langsam	mittel	schnell	schnell	sehr schnell

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2.4.0 General RFID - Technology & Frequency Overview

	Passive RFID	Active RFID	Semi-active RFID
Tag power source	Powered trough reader over RF	Battery powered	Battery and reader powered
Availability	Only while being read, no broadcasting possible	Continous, broadcasting possible	Continuous for chip/sensor, no broadcasting possible
Communication range*	**0 ~ 3m**	**0 ~ 1000m**	**0 ~ 10m**
Bulk reading	Yes, with anti-collision	Yes, with anti-collision	Yes, with anti-collision
Read / Write capable	Yes	Yes	Yes
Sensor capability	No	Yes	Yes
Data capacity	A few bytes (64, 128, 256, 1024, etc)	Up to several MB	A few bytes (64, 128, 256, 1024, etc)
Read speed *	Typically 50 tags/sec	Typically, 200 tags/sec	Typically 50 tags/sec
Size	From a few mm to credit card size	Typically as large as the battery	From a few mm to credit card size
Standards	Highly standardized	Poor standardization	Poor standardization
Tag price	Cheap	Expensive	Expensive
Reader price	Expensive	Cheap	Expensive

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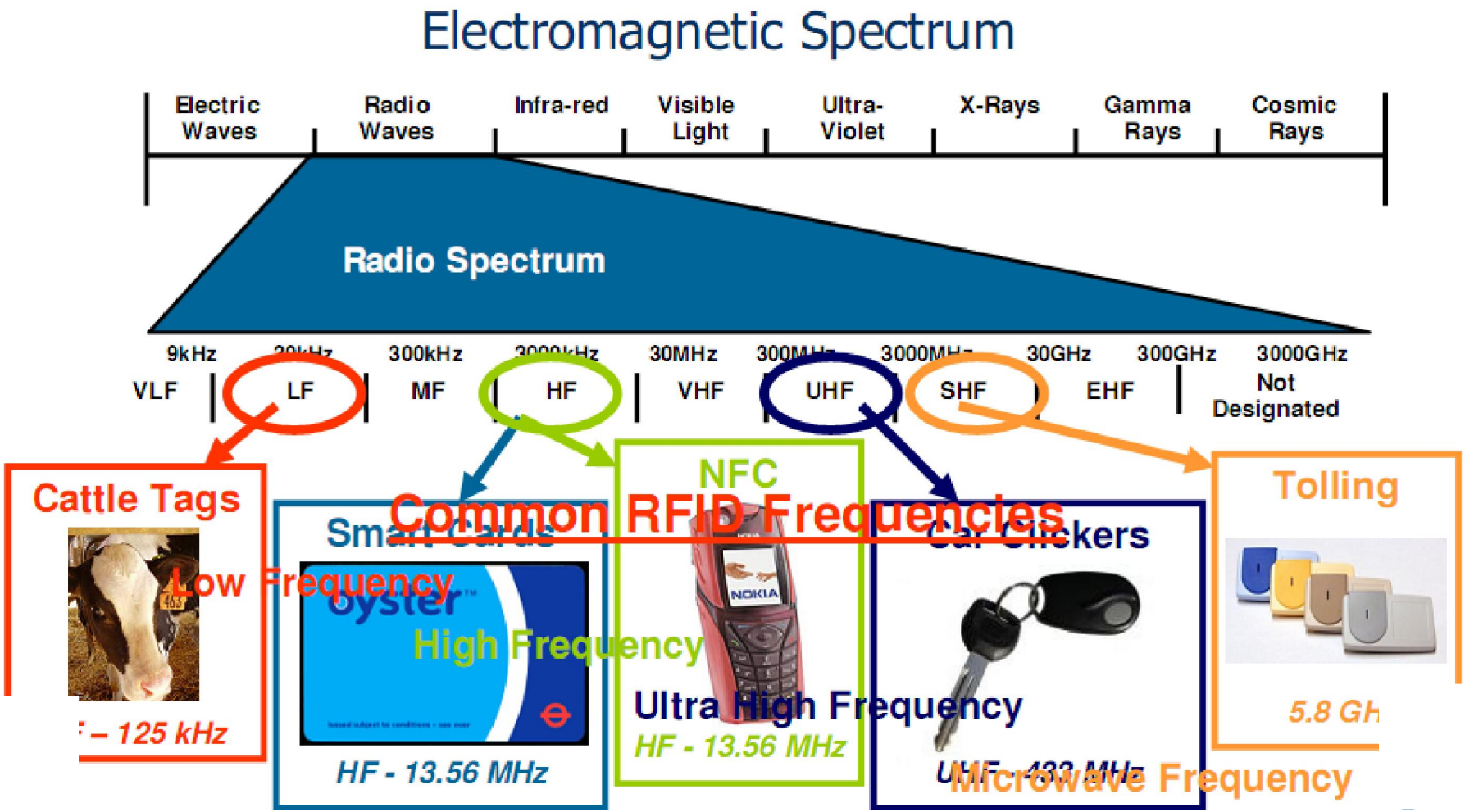
2.4.0 General RFID - Technology & Frequency Overview



2.4.0 General RFID - Technology & Frequency Overview

Frequency range	Comment	Allowed fieldstrength / transmission power
< 135 kHz	low frequency, inductive coupling	72 dBµA/m max
3.155 ... 3.400 MHz	EAS	13.5 dBµA/m
6.765 .. 6.795 MHz	medium frequency (ISM), inductive coupling	42 dBµA/m
7.400 .. 8.800 MHz	medium frequency, used for EAS (electronic article surveilance) only	9 dBµA/m
13.553 .. 13.567 MHz	medium frequency (13.56 MHz, ISM), inductive coupling, wide spread usage for contactless smartcards (ISO 14443, MIFARE, LEGIC, ...), smartlabels (ISO 15693, Tag-It, I-Code, ...) and item management (ISO 18000-3).	60(!) dBµA/m
26.957 .. 27.283 MHz	medium frequency (ISM), inductive coupling, special applications only	42 dBµA/m
433 MHz	UHF (ISM), backscatter coupling, rarely used for RFID	10 .. 100 mW
865 .. 868 MHz	UHF (RFID only), Listen before talk	100 mW ERP Europe only
865.6 .. 867.6 MHz	UHF (RFID only), Listen before talk	2W ERP (=3.8W EIRP) Europe only
865.6 .. 868 MHz	UHF (SRD), backscatter coupling, new frequency, systems under developement	500 mW ERP, Europe only
902 .. 928 MHz	UHF (SRD), backscatter coupling, several systems	4 W EIRP - spread spectrum, USA/CA only
2.400 .. 2.483 GHz	SHF (ISM), backscatter coupling, several systems,	4 W - spread spectrum, USA/Canada only
2.446 .. 2.454 GHz	SHF (RFID and AVI (automatic vehicle identification))	0.5 W EIRP outdoor 4 W EIRP, indoor
5.725 .. 5.875 GHz	SHF (ISM), backscatter coupling, rarely used for RFID	4 W USA/Canada, 500 mW Europe

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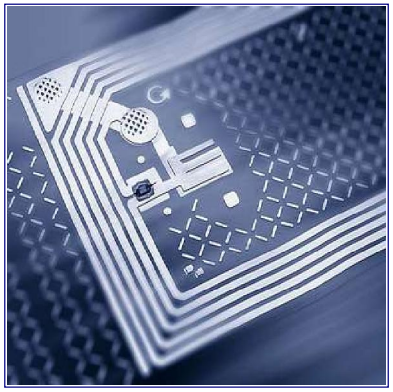
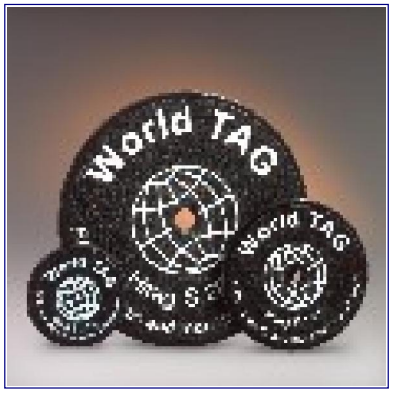
2.4.1 General RFID – passive Tags





- **Passport**
- **Credit cards**
- **Nails**
- **Inlays**
- **Animal tags**
- **Textil tags**
- **Etc**

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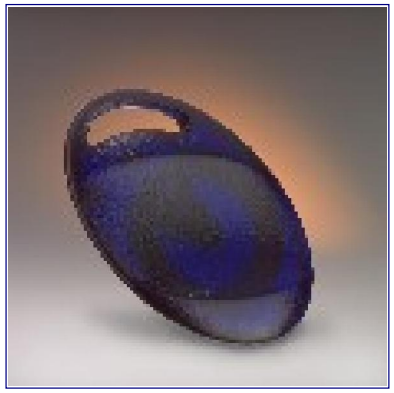
2.4.1 General RFID – active Tags



- **Wristband**
- **Credit cards**
- **Asset-Chips**
- **Keyfobs**
- **Vehicle tags**
- **Security tags**
- **etc**

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2.4.1 General - active RFID- & GPS-Tag

RFID-Reader (fix)

RFID-Reader (mobile)

Active RFID Tags

Active-RFID & GPS-Tag

http://www.identecsolutions.com/ilrlongrange.html

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2.4.2 Active RFID – Functional Overview

- Active RFID Technology
- No real standards (except : ISO 18000-7)
- Tag sends « pings » or waits for wakeup
- Readers waits for ping or sends wakeup signal
- Unidirectional or bidirectional communication
- Can have options like: motion sensor, battery monitoring, GPS input, temperature monitoring, etc

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2.5 Indoor – Positioning Techniques

- **RTLS - 3 big families**
  - Triangulation / Angulation
  - Cell-based
  - Choke-point based
- **Identify AND locate**
- **Vision:**
  - Every person and object in a building is identified and located in real-time
- Location enables software applications
- Connects the real world to the virtual world
- RTLS is usually referring to indoor tracking or local positioning (contrary to outdoor GPS)

- **Used in:**
  - Hospitals (find assets, people)
  - Industry (WIP-Tracking)
  - Army (Combat training)
  - Container Management (Cargo)
  - Tourism (Auto-guides)
  - Security (Alarm localisation)
  - etc.

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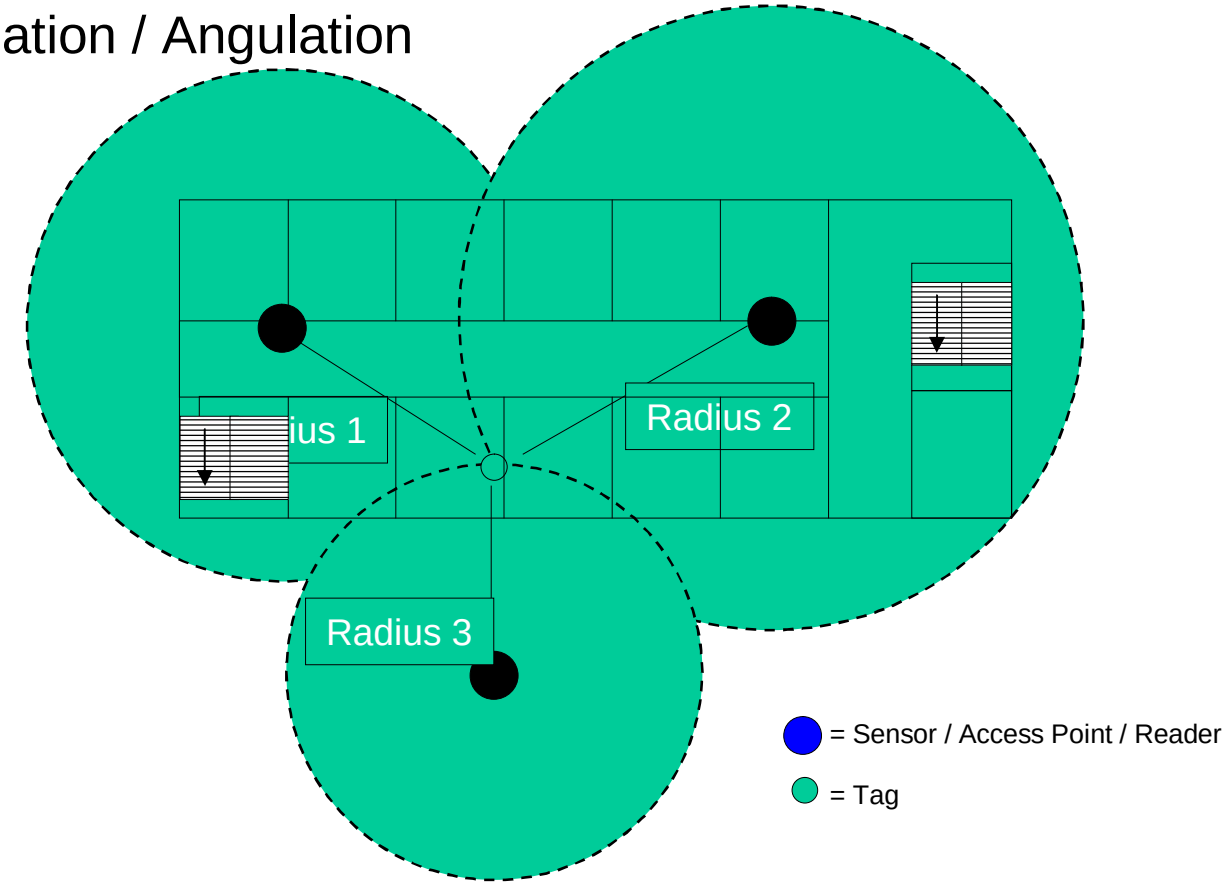
2.5.1 Indoor – Positioning Techniques

- Triangulation / Angulation



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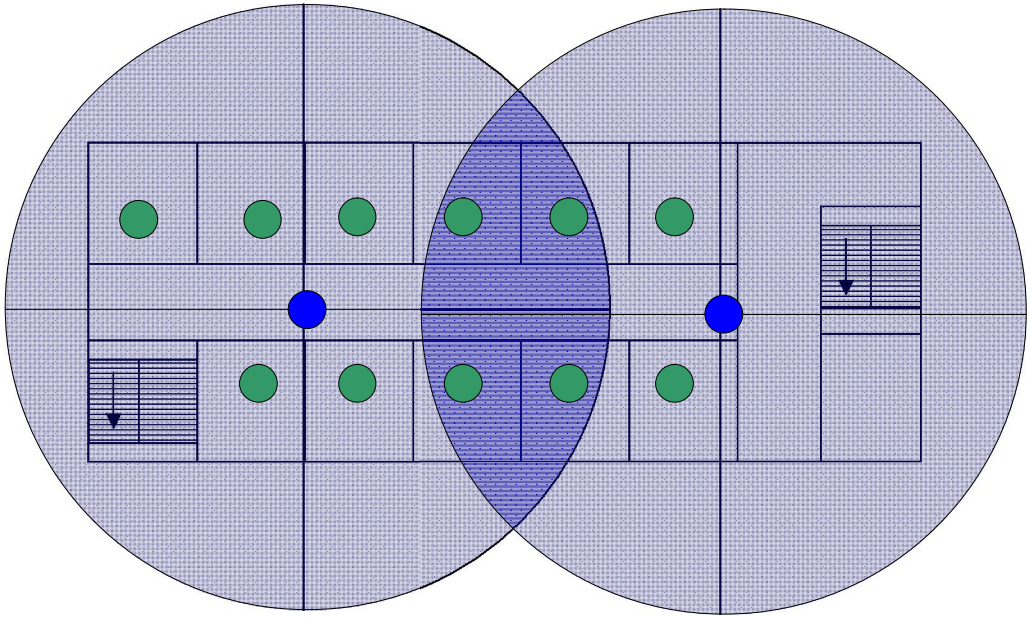
2.5.2 Indoor – Positioning Techniques

- Cell-Based



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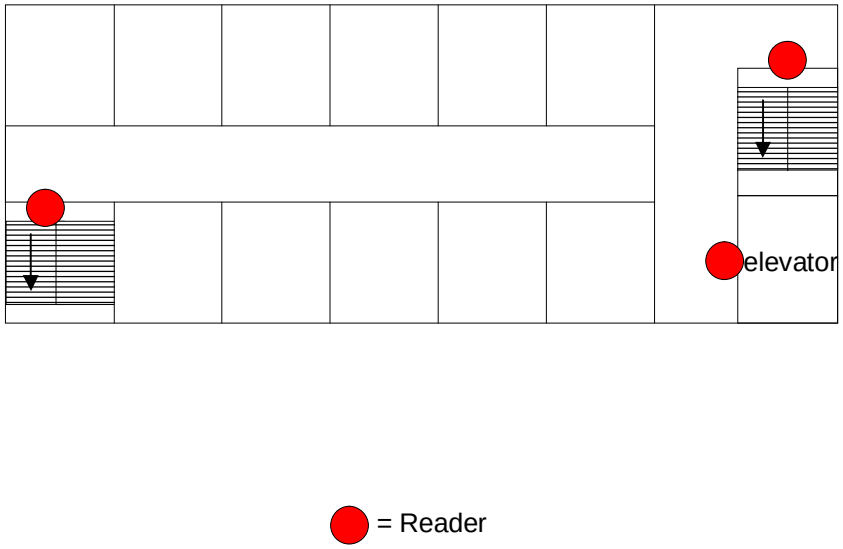
2.5.3 Indoor – Positioning Techniques

- Chokepoint based



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2.6.1 Indoor RTLS - active RFID based

- Active RFID Technology
- No real standards (except : ISO 18000-7)
- Tag sends « pings » or waits for wakeup
- Readers waits for ping or sends wakeup signal
- Unidirectional or bidirectional communication
- Can have options like: motion sensor, battery monitoring, GPS input, temperature monitoring, etc

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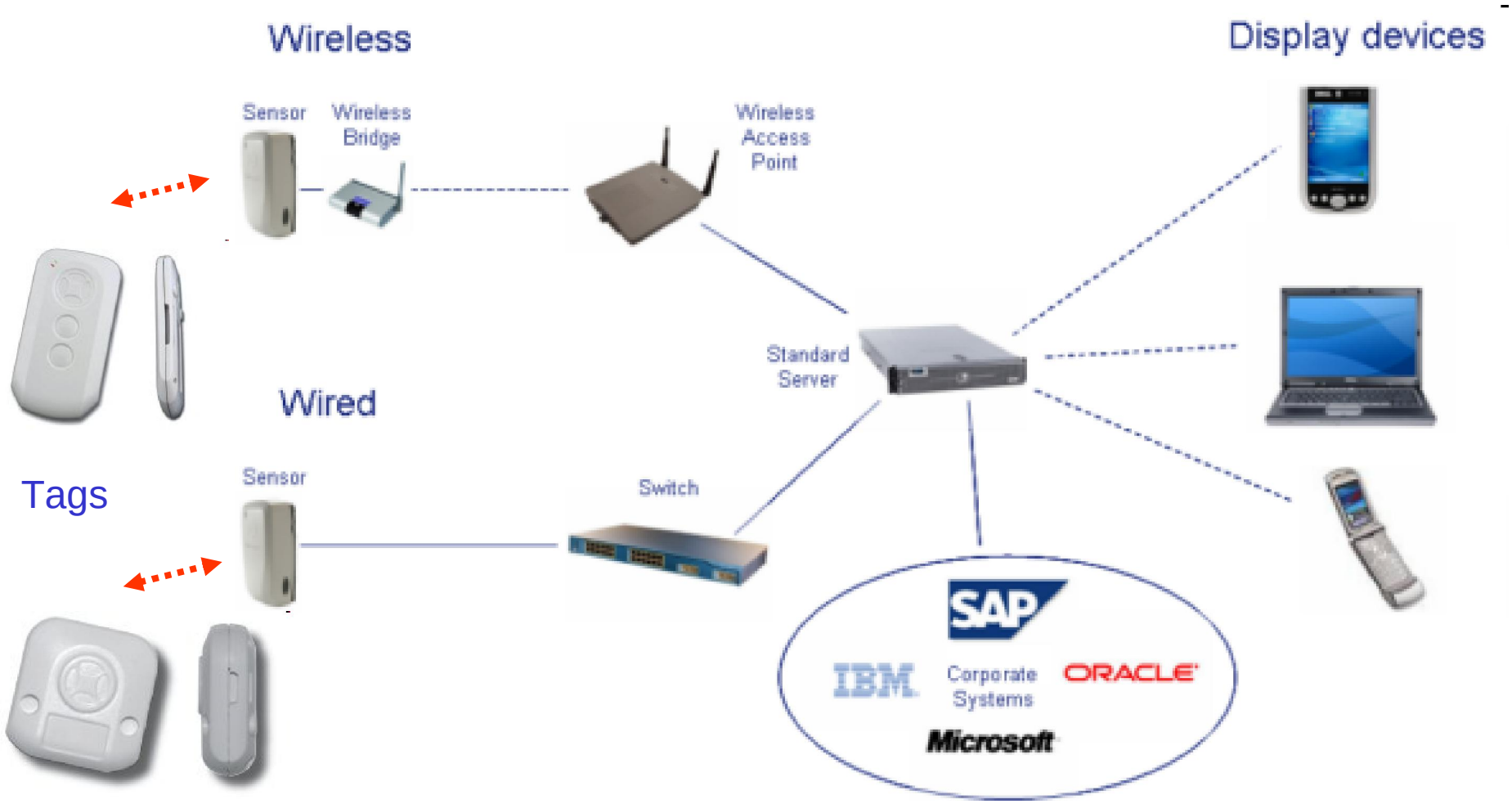
2.6.1 Indoor RTLS - active RFID based



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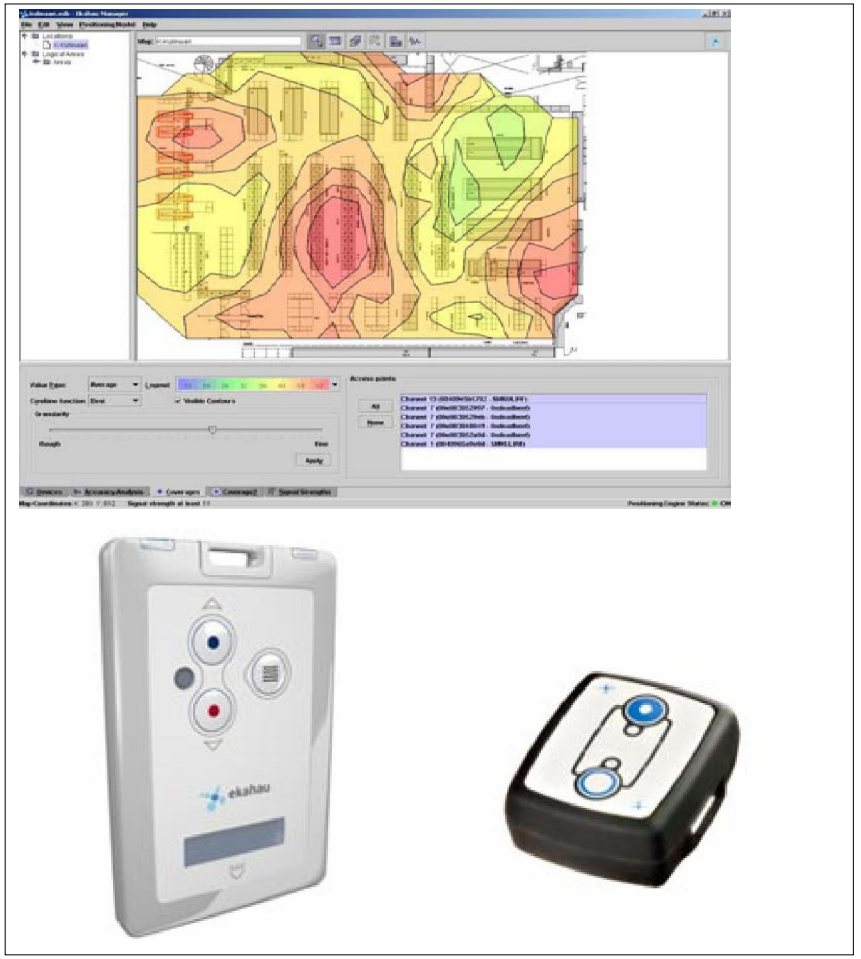
2.6.2 Indoor RTLS - WLAN based

- Access Points = Readers
- Triangulation of WLAN tags
- Radio-Map needed
- Calibration may be needed
- Tag or reader RSSI sensing
- Full WLAN client tags or only 802.11b/g beacon tags
- WLAN ready Laptops / PDAs can be located
- Can leverage existing infrastructure, but…
- Needs high density of APs! (good if already VoIP-enabled WLAN)
- Description see …



http://www.ekahau.com/?id=1012

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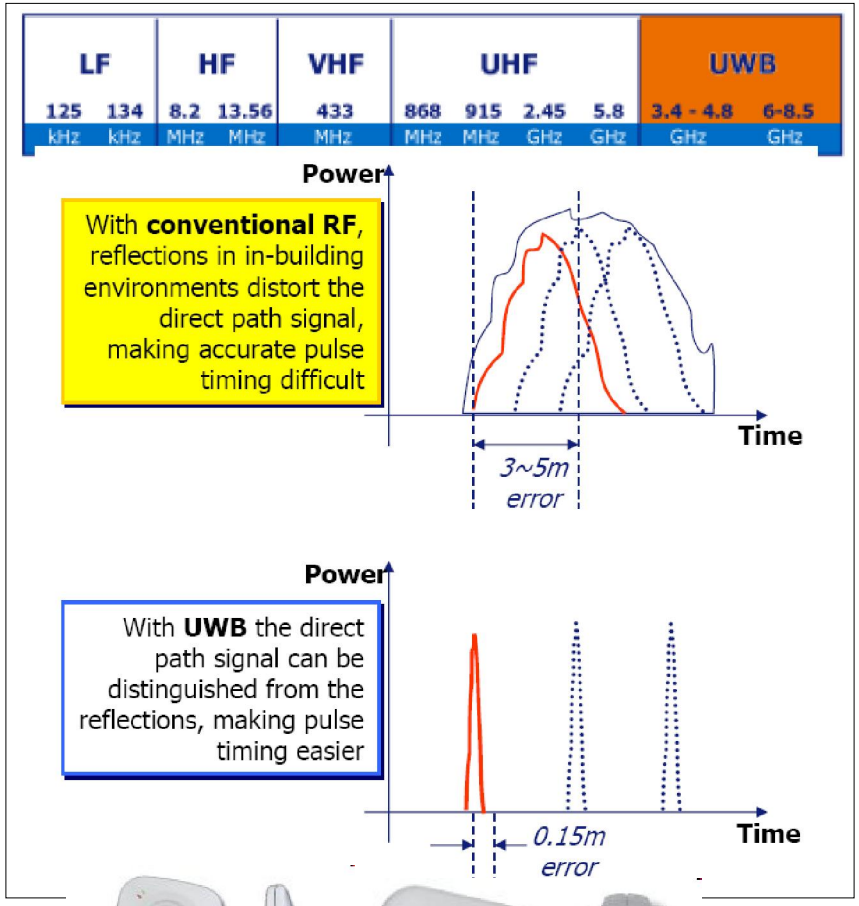
2.6.3 Indoor RTLS – UWB based

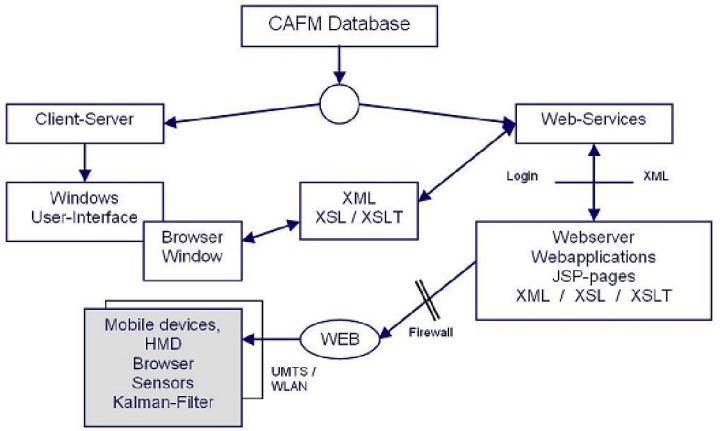
- Ultra Wide Band technology
- Wide spectrum, short pulses
- Precision up to 15cm in 3D!
- Very new technology (just been approved in EU in 2007 and CH in 2008)
- Combined TDoA and SS
- Sensors connected with timing cable
- Usually 4 sensors needed for one « cell »
- Localization with
  2 sensors à 30cm
  3 sensors à 15cm
- Demo see …

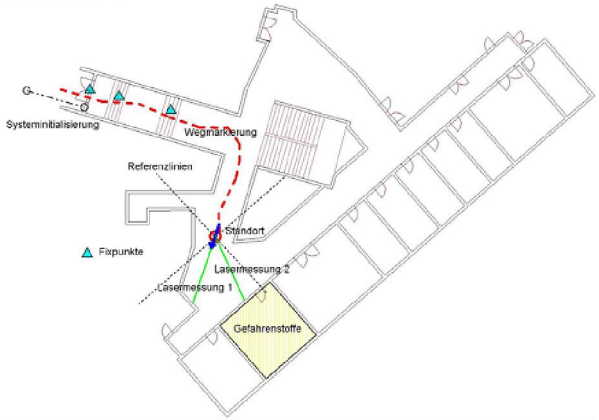
  http://www.ubisense.net



2.6.4 Indoor RTLS - e-INS based

- Electronic-Inertia-Navigation-System (analogue airborne Nav.)
- Precision up to ~5m in 3D !
- Very new technology: based on e-INS HW and …
- SW from Bauinformatik@TU Graz
- Autonomouse, autarc System as CADMS
- Localisation via Refernce-Point + Inertia Vector
- Disadvantage: needs GPS-Synchronisation or Building Plans





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3. Tomorrow's RTLS-World

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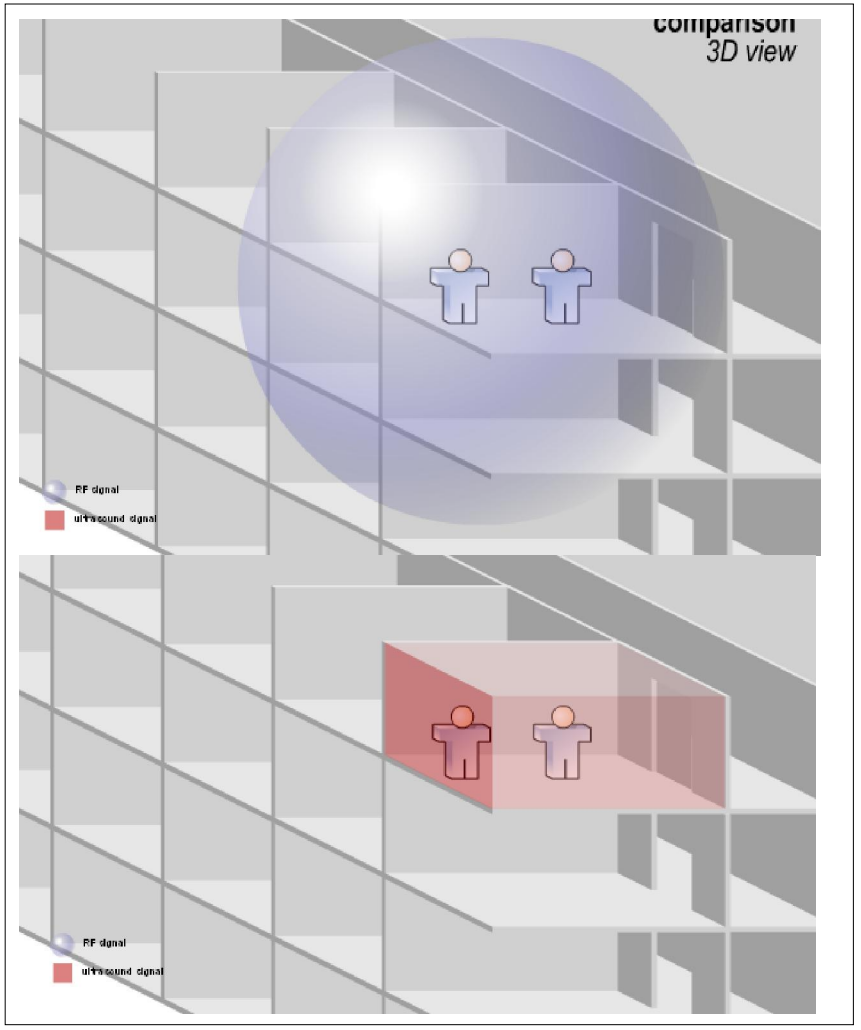
3. Tomorrow‘s RTLS Systems (combined technologies)

- Infrared RTLS
  - Room localisation possible
  - Think « TV remote control »
- Ultrasound RTLS
  - Room localisation possible
  - Think « bat »
- GPS assisted RTLS
  - Get data from GPS
  - Combine with local RTLS
  - Get precise localisation on open fields (airport)
- Distance measurement RTLS
  - Think « radar » with active RFID



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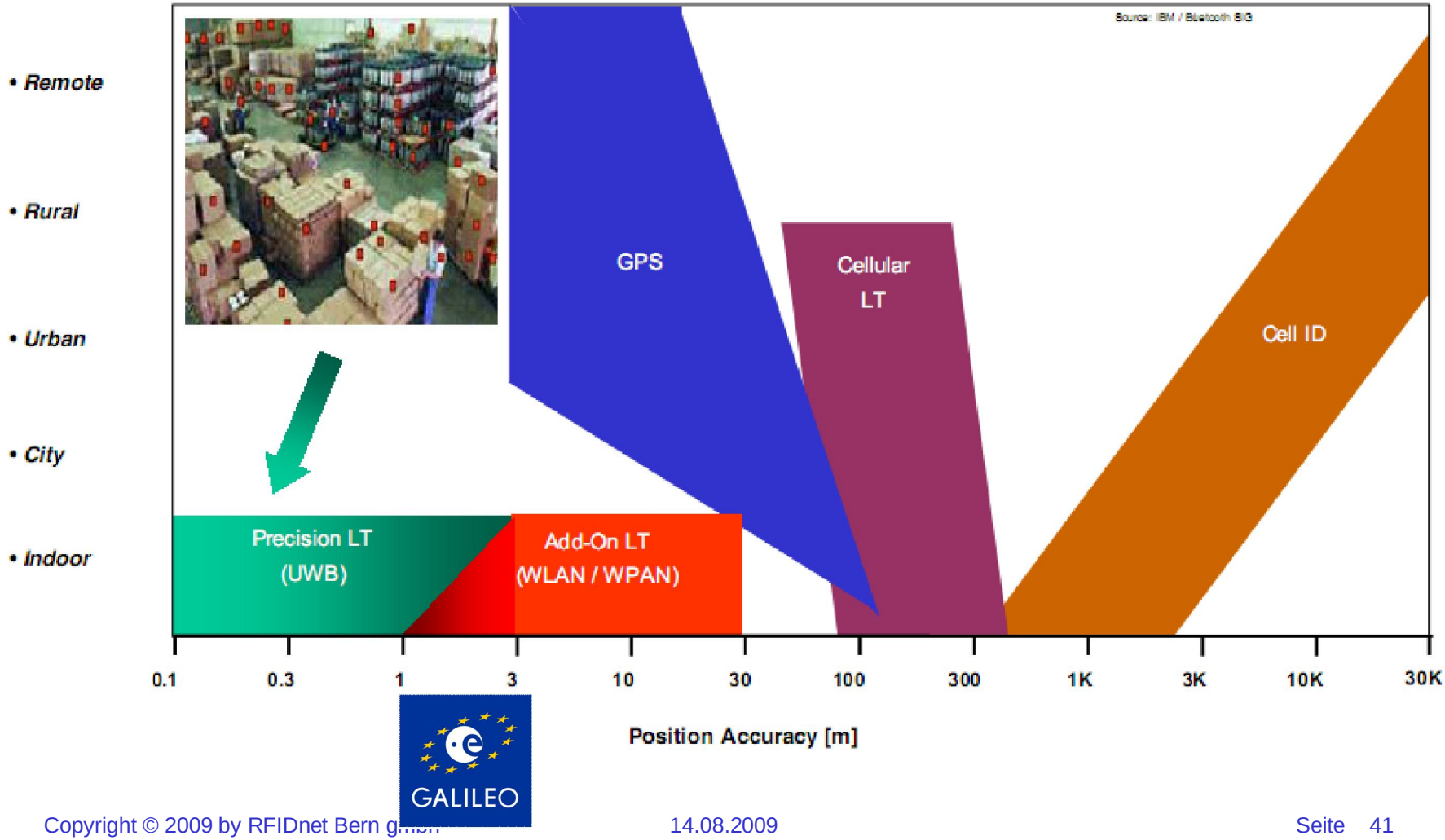
à Position Accuracy RTLS (in- & outdoor)



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4. Questions ?

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Organisations

AIM Global	www.aimglobal.org
AIM D/A/CH	www.aim-d.de
EU-RFID …	http://www.rfidconsultation.eu/
European GS1 ….	http://www.gs1.org/
European EPC Global …	http://www.epcglobalinc.org/about/about.html
ISO ….	http://www.iso.org/iso/en/ISOOnline.frontpage
CEN …..	http://www.cenorm.be/cenorm/index.htm
ETSI …..	http://www.etsi.org/home.htm
AutoID …..	http://www.autoidlabs.org/aboutthelabs.html
RFID-Consultation	http://www.rfidconsultation.eu/menu/rfid-directory/db/
RFIDnet Bern GmbH	www.rfidnet.ch
Odette	www.odette.org
AIAG	www.aiag.org
Oasis	www.oasis.org
AutoID Labs	www.autoidlabs.org

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Publications

RFID-Journal	www.rfidjournal.com
RFID-Update	www.rfidupdate.com
RFID-Exchange	www.rfidexchange.com
RFID im Blick	www.rfidimblick.de
RFID Solutions Online	www.rfidsolutionsonline.com
RFID Gazette	www.rfidgazette.org
RFID IDtechx	www.idtechx.com
Info RFID Deutschland	http://www.info-rfid.de
RFID Ready	www.rfid-ready.de
RFID ABC	www.rfidabc.de

Portals

RFID-Portal Link	http://www.rfidlinks.de/

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Portals

http://www.aimglobal.org

- AIM Inc.:
  is the global trade association for the Automatic Identification and Data Capture (AIDC) industry. Covering technologies such as barcode, rfid, card technologies (magnetic stripe, smart card, contactless card, optical card), radio frequency data communications (RFDC), biometrics, and electronic article surveillance (EAS).
-
- http://www.rfidbusiness.org
- The International RFID Business Association (RFIDba) is an International, Not-for profit, Vendor neutral, Educational, Trade Association. The RFIDba is focused on serving the needs of End Users who have a real need for educational programs that will help them in achieving a successful deployment and implementation of RFID technologies in their business.
-
- http://www.epcglobalinc.org
- EPCglobal:
  is leading the development of industry - driven standards for the EPC to support the use of RRID in today´s fast-moving, information rich, trading networks. A subscriber-driven organisation comprised of industry leaders and organisations focused on creating global standards for the EPCglobal Network.
-
- http://www.rfidsolutionsonline.com
- RFID Solutions Online:
  provides its readers with news and insight into RFID Solutions News and information.
-
- http://www.rfidresellers.com
- IT Backbones is an innovative network of websites that spans the global IT industry to provide latest news and vital sourcing information directly to your browser, absolutely free of charge.
-
- http://www.rfidaa.org
- RFID Australia:
  RFID Action Australia is an industry cluster which will assist in the development of expertise and experience with RFID within Victorian companies.

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Portals

- http://www.rfidnederland.nl
- RFID Nedderland:
  Dutsh RFID Plattform.

- http://www.rfididensbank.dk
- RFID Vidensbank:
  Siden der samler viden om RFID i Danmark.

- http://www.rfidtribe.com
- RFID Tribe:
  a global organization with local chapters, is a rapidly growing forum for radio frequency identification. RFID Tribe has members in over 50 countries and in more than 300 companies.

- http://www.rfid-chips.net
- rfid-chips.net
- Wissenswertes rund um die Übertragung von Identifikationsmerkmalen via Funk (Radio Frequency IDentification / RFID) – einer Schlüsseltechnologie der Zukunft. rfid-chips.net ist ein redaktionelles Angebot der Kommunikationsagentur Schrader.

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Thank you for your attention

Merci pour votre attention

Danke für Ihre Aufmerksamkeit

Spaciba / Kiitos / Gracias / Grazie / Toda Raba

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