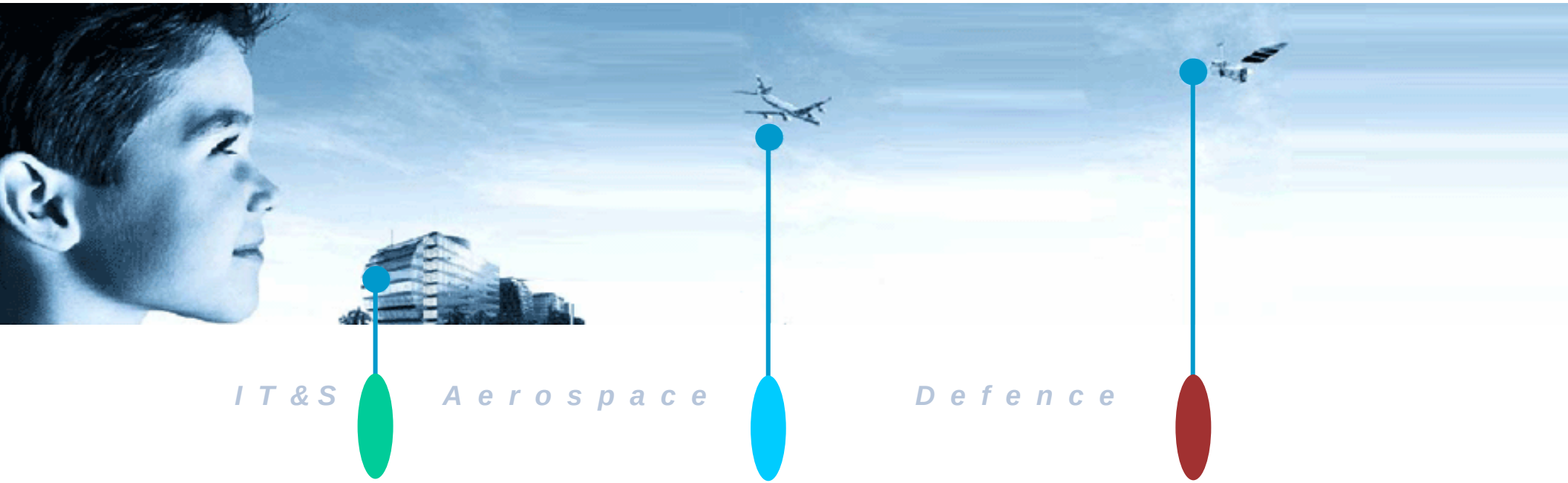
Draadloze communicatietechnologie: Een storende en/of stralende toekomst (?/!)



Prof. dr. Frank Leferink
Technical Authority EMC, Thales Netherlands
Manager Centre of Excellence EMC, Thales Group
Telecommunication Engineering, University of Twente

Content

- **Moore's Law for IC's: doubling every 18-24 months.**
  For communication systems: doubling every 6 months(!)
  In 2006 more information can be sent over a single cable in a second than in 1998 was sent over the entire Internet in a month.
- **Wireless systems will be anyplace, anytime, anywhere, and systems not-designed-for, will be used in other environments**
  Example: WLAN and Bluetooth in industrial areas
- **People and all their "things" communicate spontanously**
  From 1 one transmitter per thousands of persons in the broadcast age, via one transmitter per person in the mobile phone age, to hundreds of tiny wireless devices per person in the ubiquitous networking age
- **Networking technology will transform from a highly visible "hi-tech technology" to a "disappearing technology" that everyone can afford, use and deploy (and auto-everything and low-cost)**
- **In this presentation:**
  - **Trends**
  - **New concepts under investigation**

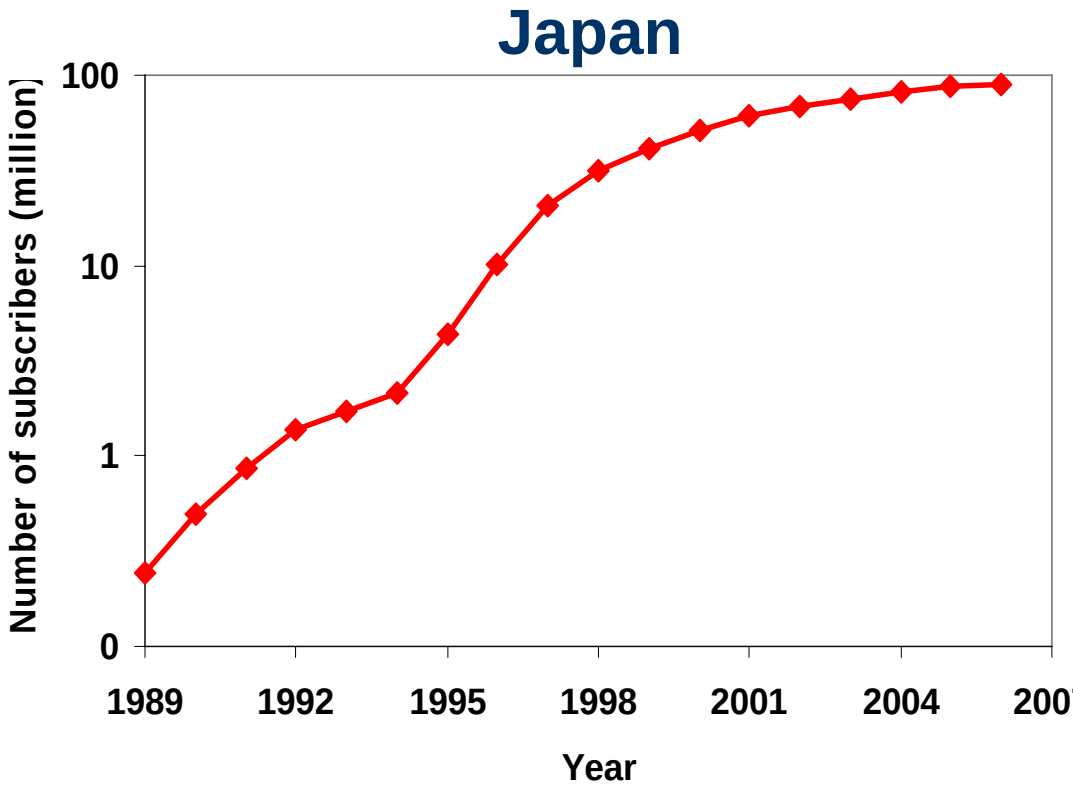
  Taking EMC and ESD issues into account

GSM subscribers in Netherlands and Japan, 2005

GSM Subscribers	Total E-GSM	Total GSM-900	Total GSM-1800	GSM Penetration
14.8 million	2 x 10.0 MHz	2 x 23.8 MHz	2 x 72.0 MHz	92.5 %

Operator	No. of Subscribers
KPN Mobile	5.8 million
Vodafone	3.5 million
Orange	1.5 million
Telfort	1.7 million
T-Mobile	2.3 million

Source: CEPT

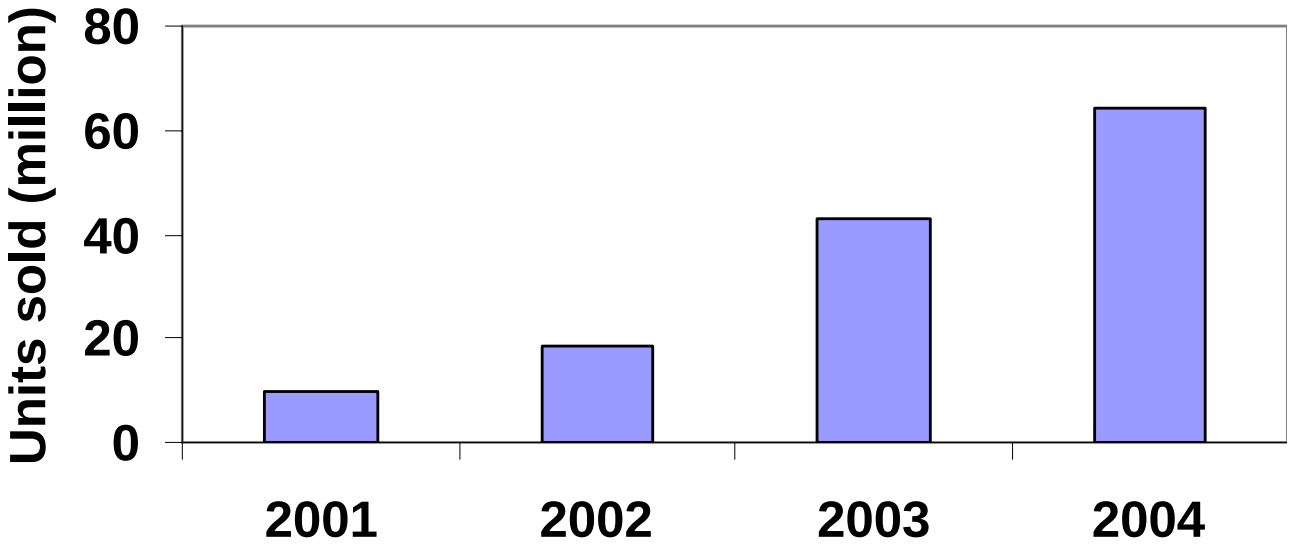


Number of 3G subscribers, WLAN units

3G subscribers, year end 2005

Japan	40 million
South-Korea	36 million
European Union	10 million
Australia	0.75 million
Hong Kong	0.45 million
United States	0.25 million

WLAN units:

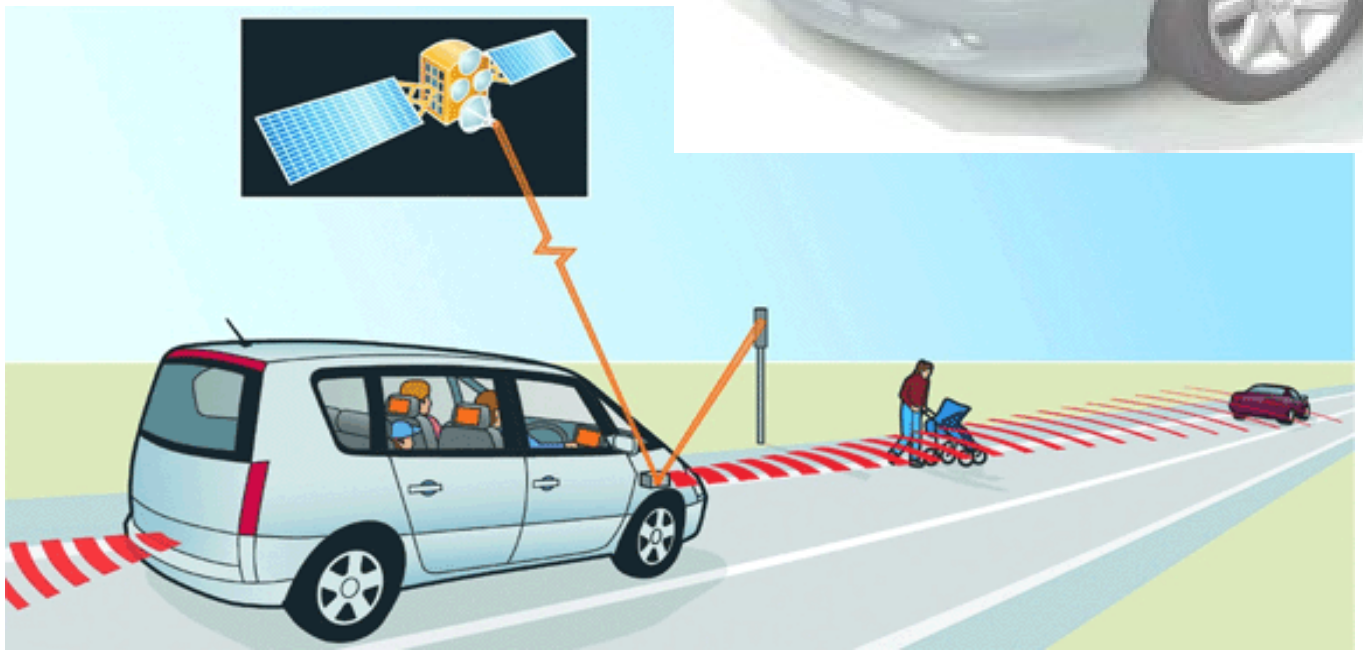


- **Social trends:**
  - Security and safety in our daily living environment
  - Safety anywhere, including transport (such as tracking, drive-by-wire, brake-by-wire, steer-by-wire)
  - Health and medicine, including the risks of Electromagnetic fields (EMF), and pollution, and an increased demand for better medicine
  - Just-in-time society, i.e. people are not willing to wait for unknown amount of time
  - Home automation, i.e. domotica (such as flexible infrastructure, mix of data and energy, media comfort, healthcare-at-home, air quality)
  - Connected anywhere, everywhere, anyplace, any-time, any network on any device, right content, secure, low energy, ubiquitous networks
  - etcetera

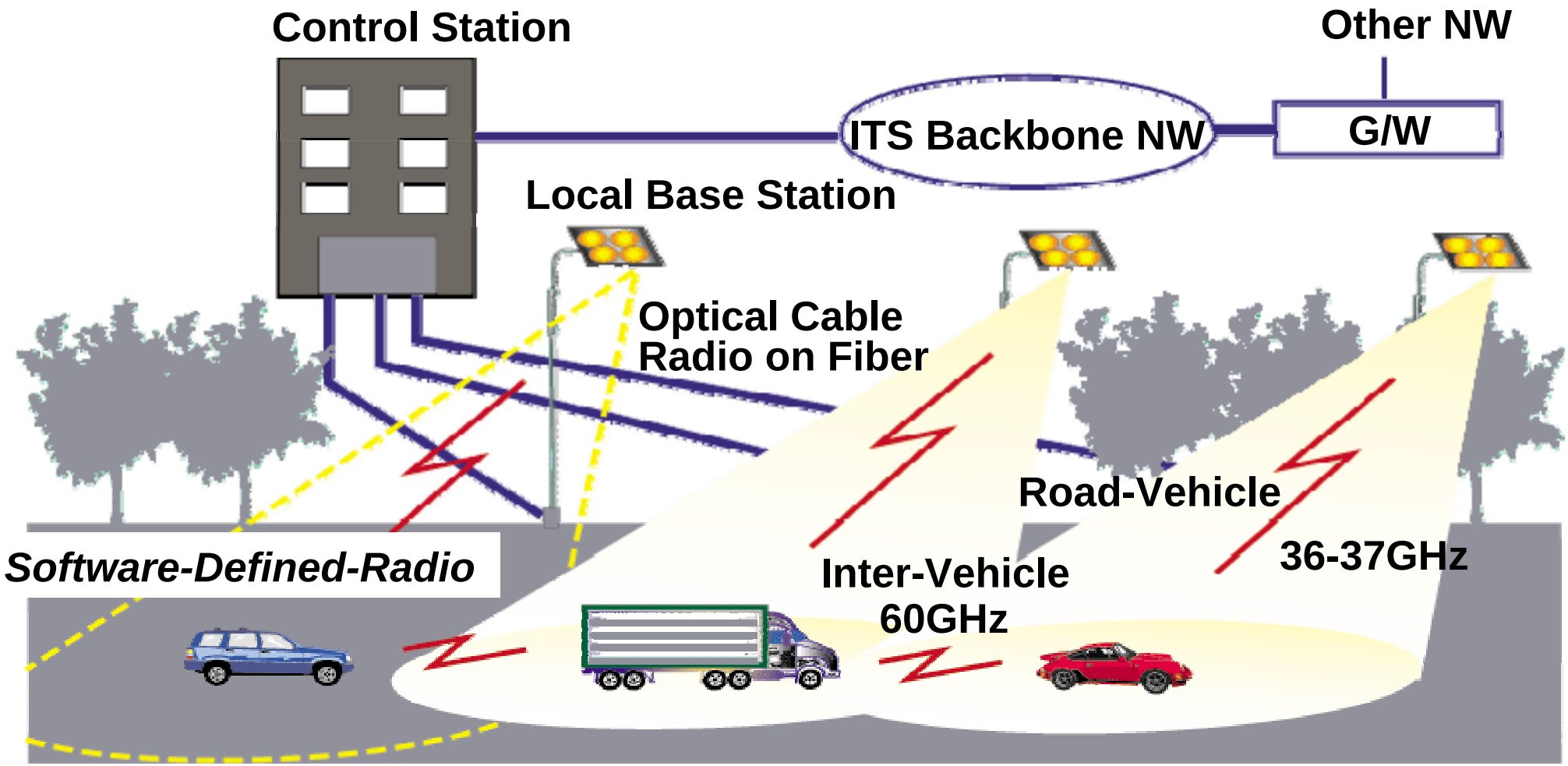
- **Economical trends:**
  - More functionality
  - Less space, less costs, and thus
  - Mass production in China
  - Etcetera
- **Social and economical trends result in technological needs and therefore a market pull (instead of market driven) trend. Examples**
  - Safety trend will put an emphasis on the need for hardened electronics and sensors (i.e. RFID) against Intentional EMI.
  - Reduction in air pollution will push the need for smart sensors in automotive applications.
  - The trend for a healthy society will reduce the amount of psychoactive drugs which can by nerve stimulators using radio-frequency signals.

- **Transport**
  - Cars, planes, vessels, and trains are more and more controlled by sensitive electronic systems, which make these transportation systems sensitive for electromagnetic interferences. The electronics inside the transportation systems are causing interference with radio communication systems.
  - New transport applications with an EMC impact are: automatic driving with fail safe technology, radar technology for sensing obstacles and objects, intelligent traffic/weather sensors, wireless networking technology in and between cars, etc.
  - Many systems, especially airplanes, are poorly screened against electromagnetic fields due to the replacement of metal by composite materials, resulting in many vulnerable systems.

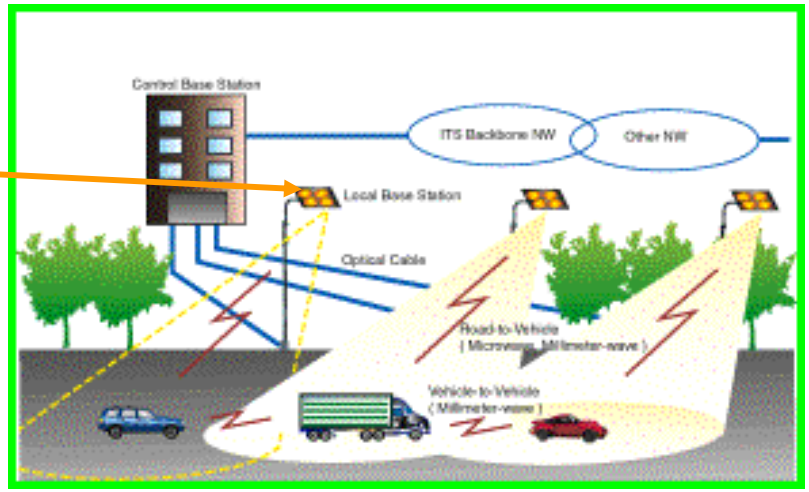
Trends, 4



Integrated Traffic Communication System



ITCS tests in Yokosuka Research Park



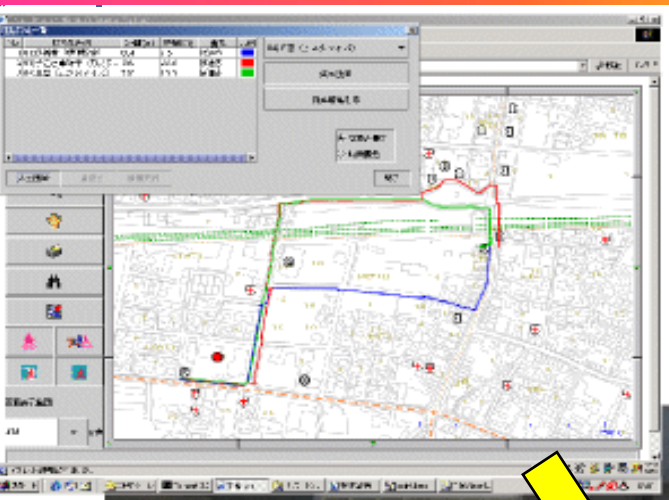
Back vehicle (Receivers)

Front Vehicle (Transmitter)

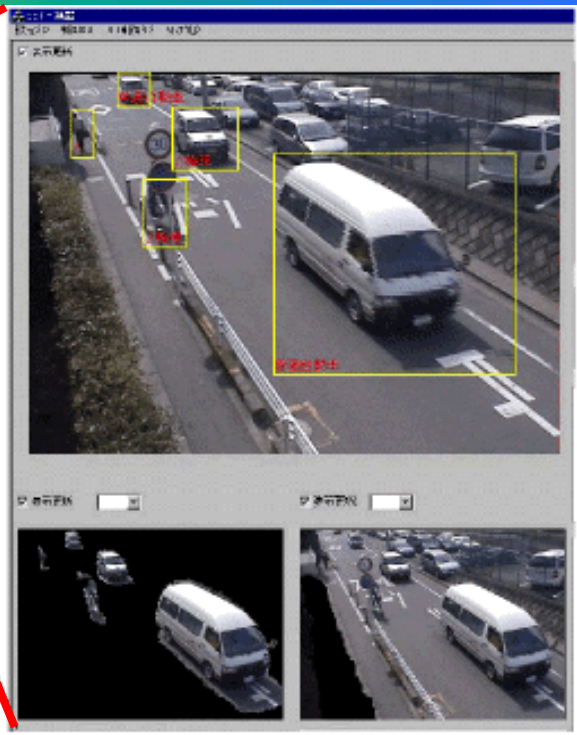
Antenna & RF Devices for Diversity

Antenna & RF Devices


TROS



Information post and Environment Monitor Camera



Touch Panel

Camera

GPS

PC

Wireless LAN

Battery

Infrared, Supersonic Sensors

The Jammed Wheelchair: A Case Study of EMC and Functional Safety

Dick Groot Boerle[1], *Frank Leferink*[1,2]

1 *Thales Netherlands*
P.O. Box 42
7550 GD Hengelo
The Netherlands
dick.grootboerle@nl.thalesgroup.com

2 *University of Twente*
P.O. Box 214
7500 AE Enschede
The Netherlands
frank.leferink@utwente.nl

Abstract: The assessment of the influence of electromagnetic phenomena on the functional safety of electric equipment can be improved. The product standards for electric equipment with safety relevant functions still focus on the functional behaviour. The EMC requirements are quite often composed by following the same approach as for the Generic Standards for the EMC Directive in which only two environments are taken into account. In order to explain this and to show a better approach, a case study has been carried out. The essence of this case is an accident with an electric wheelchair where the culprit was a GSM-phone booster. Point of interest is that the wheelchair did meet the relevant product standard for electric wheelchairs. The shortcomings of this standard with respect to EMC have been established. In addition, it is shown that an assessment should start with an inventory of the environments in which the product might be operated. This improved assessment is in line with the relatively new IEC Technical Specification 61000-1-2: 'Methodology for the achievement of functional safety of electrical and electronic equipment'.

I. Introduction

Figure 1. An ordinary street with cars and an electric wheelchair: one environment – different EMC requirements.

Rolstoelen op hol door gsm's

Van onze Haagse redactie 23/2/98

WOERDEN, maandag

Mobiele telefoons kunnen een elektrische rolstoel op hol doen laten slaan. Door de straling die vrijkomt bij het gebruik van de zaktelefoon kan de afstandsbediening van de rolstoel in werking treden.

Dat zegt de belangenorganisatie voor mindervaliden, KBOH in Woerden. Volgens deze instelling zijn door het gebruik van gsm-toestellen de laatste twee jaar diverse klachten binnengekomen van rolstoelers die op hol zijn geslagen.

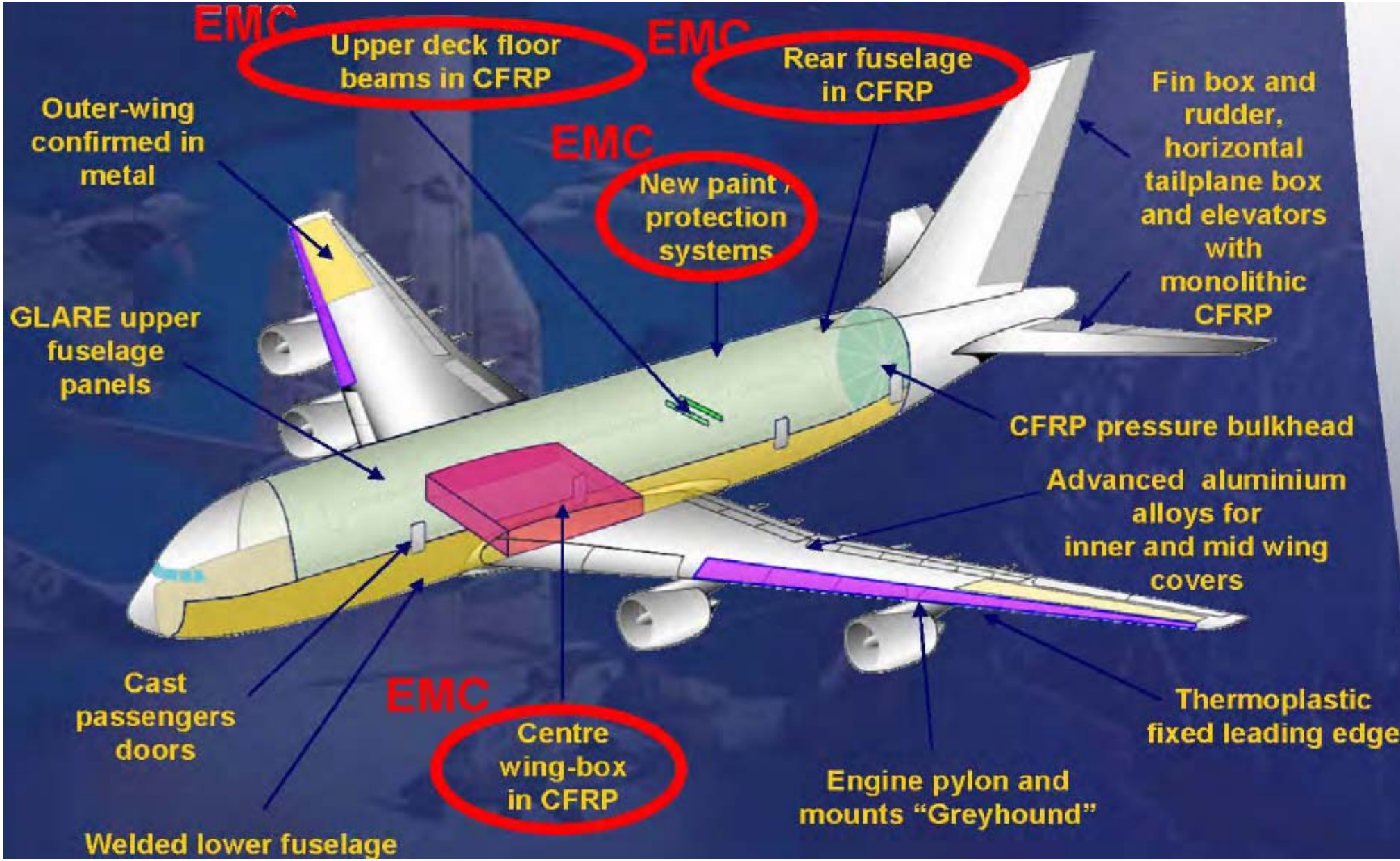
De organisatie spreekt van levensgevaarlijke toestanden. Verschillende keren zijn rolstoelers al als gevolg van de mobiele telefoon in vijvers en sloten terecht gekomen.

De KBOH raadt lichamelijk gehandicapten dan ook aan hun klachten te deponeren bij de overheid.

Het Staatstoezicht op de Volksgezondheid raadt op invaliden op zijn beurt aan hun rolstoel te laten onderzoeken op de gevoeligheid van elektromagnetische straling. Vaak blijkt namelijk dat de elektronica van de rolstoel niet goed is beschermd, waardoor mobiele telefoons deze ongewild in werking kunnen zetten.

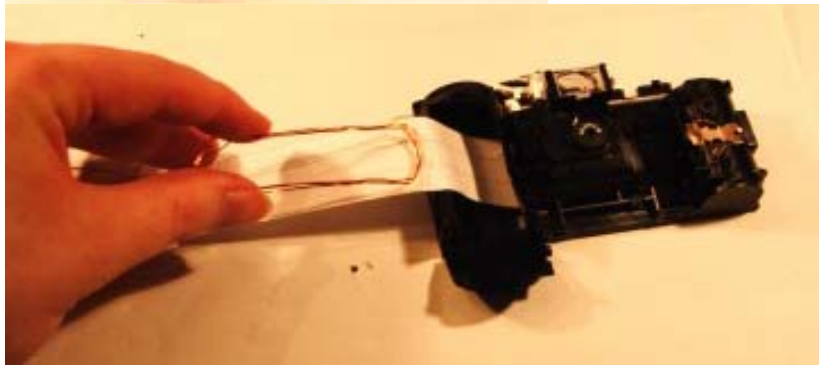
Volgens de KBOH betreft het met name oudere rolstoelen, waaraan door ondeskundigen veranderingen zijn aangebracht.

Om dit soort problemen te voorkomen dient vooral kritisch te worden gekeken naar de isolatie van het elektrische circuit van de rolstoel.


EMC
Upper deck floor beams in CFRP
EMC
Rear fuselage in CFRP
EMC
New paint / protection systems
Outer-wing confirmed in metal
Fin box and rudder, horizontal tailplane box and elevators with monolithic CFRP
GLARE upper fuselage panels
CFRP pressure bulkhead
Advanced aluminium alloys for inner and mid wing covers
Cast passengers doors
EMC
Centre wing-box in CFRP
Thermoplastic fixed leading edge
Engine pylon and mounts "Greyhound"
Welded lower fuselage

- Intentional EM interference (terrorism)

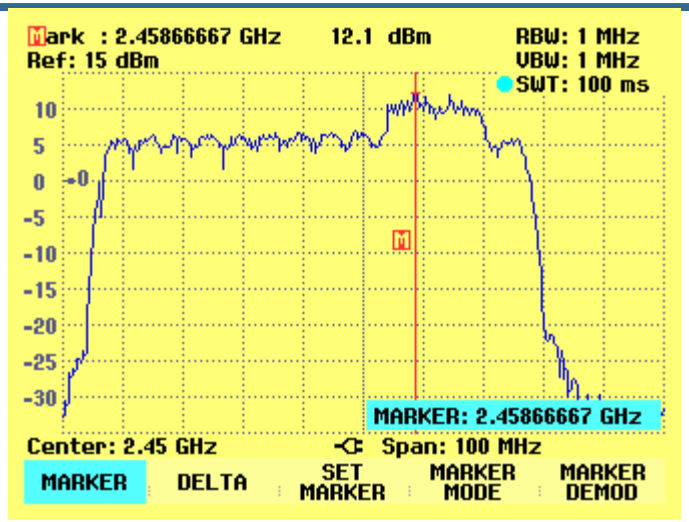
RFID zapper in camera housing



E-bomb above city

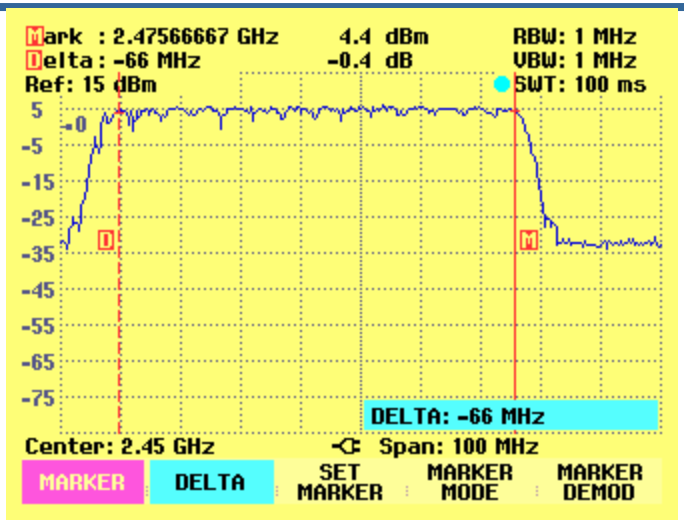
Intentional EMI: Goldeneye

Intentional EMI test



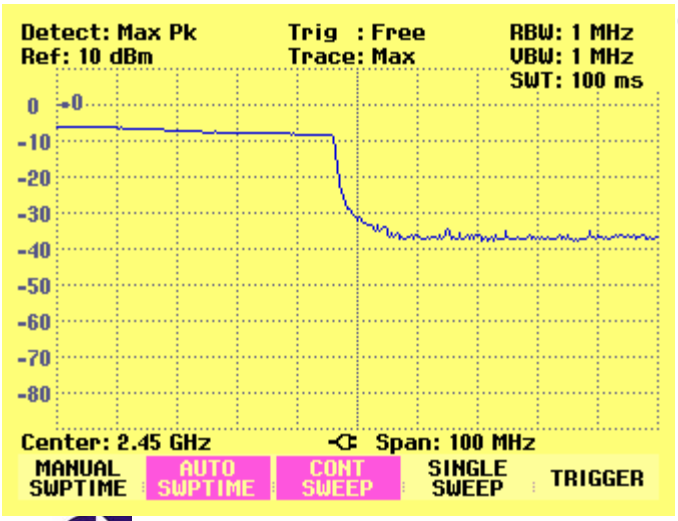
WLAN spectrum

WLAN, 2.4 GHz. The third non-overlapping channel is used for data transmission, channel 11. The other channels get polled to check if there are other clients trying to ect.



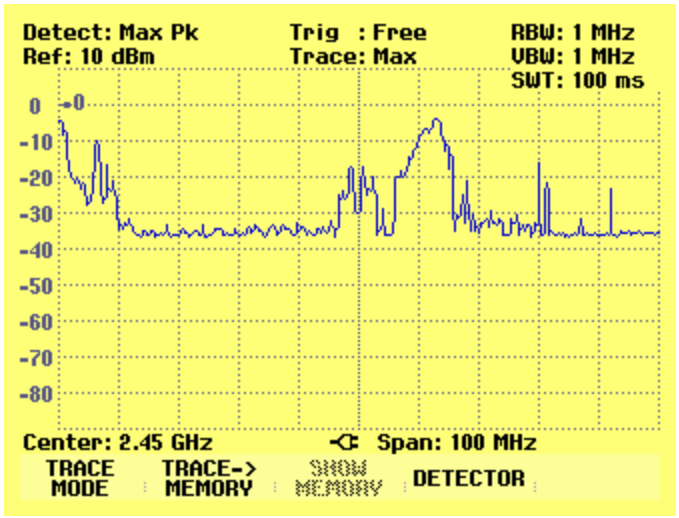
BlueTooth spectrum

Due to the hopping of the signal and the fact that the frequency hops cover the entire spectrum, the Bluetooth spectrum looks very flat.



Signal generator

Microwave oven (kitchen)

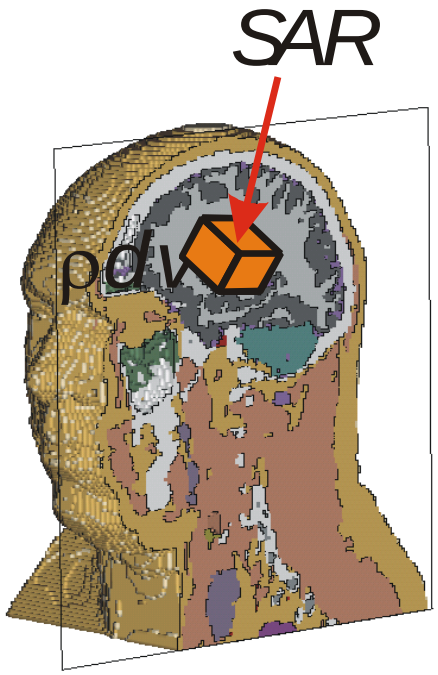


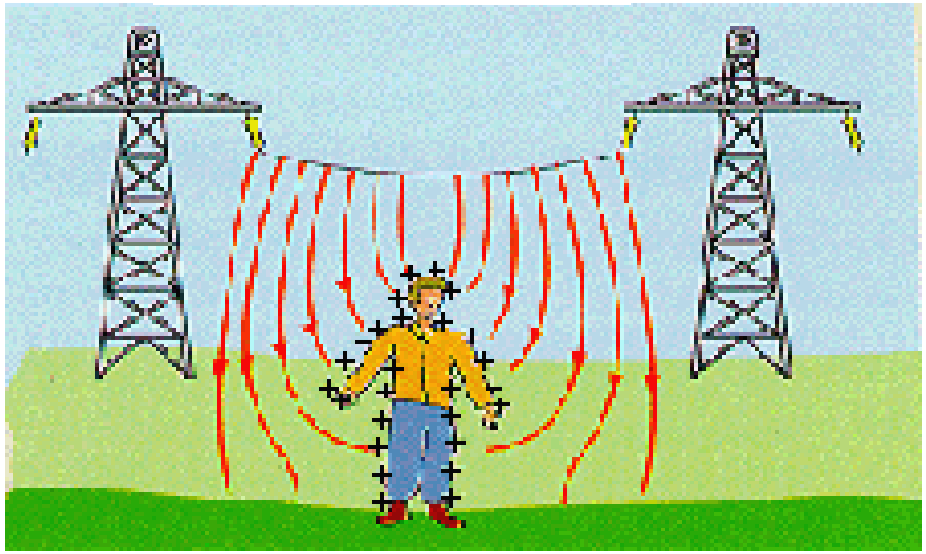
Intentional EMI test

Throughput	Non-reflecting environment		Reflecting environment	
	WLAN	Bluetooth	WLAN	Bluetooth
no interference	100%	100%	100%	100%
Bluetooth	50%	100%	46%	100%
WLAN	100%	68%	100%	54%
Cell phone 1.8 GHz	80%	85%	73%	85%
Microwave oven	51%	17%	44%	0%
Intentional signal	0%	15%	0%	0%

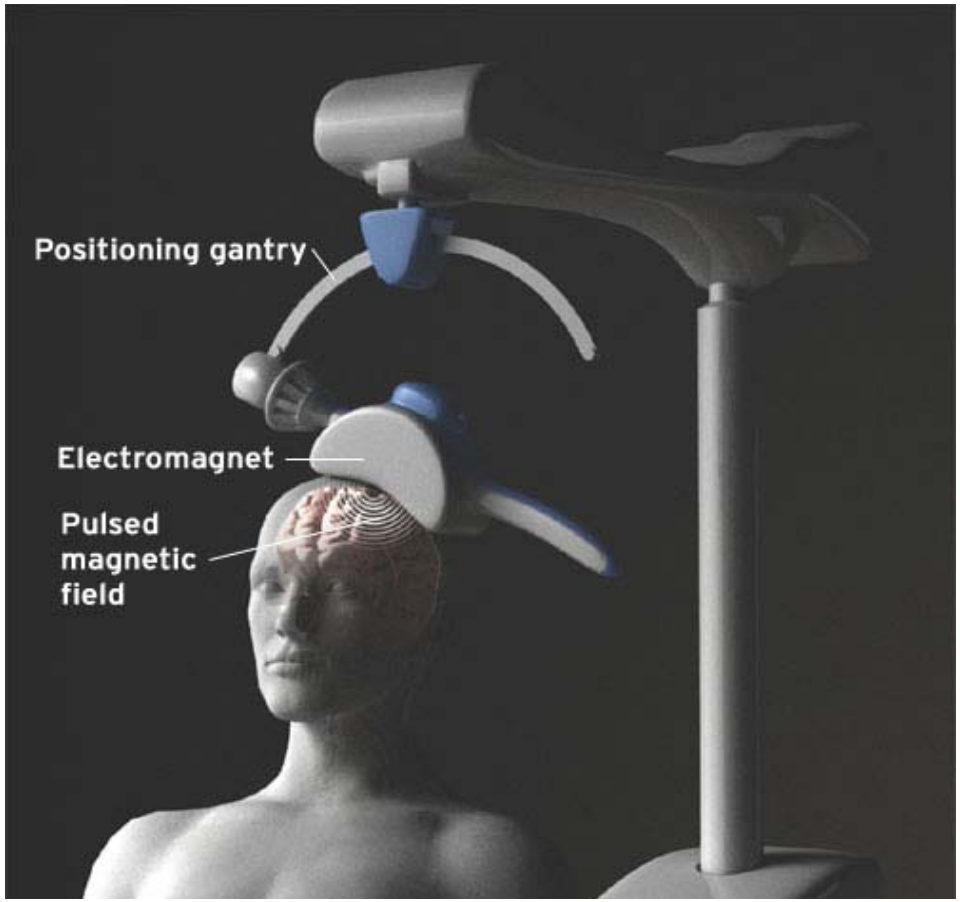
Published at the EMC Europe Conference, 2004

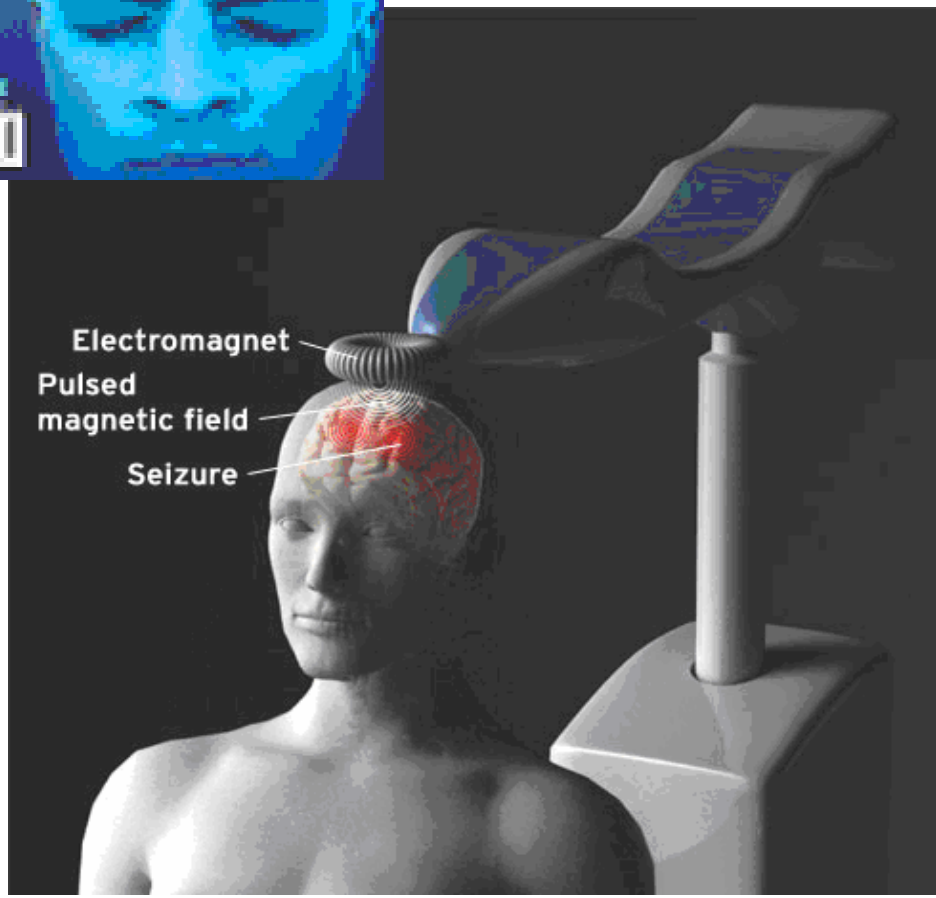
- **Biological unwanted effects**



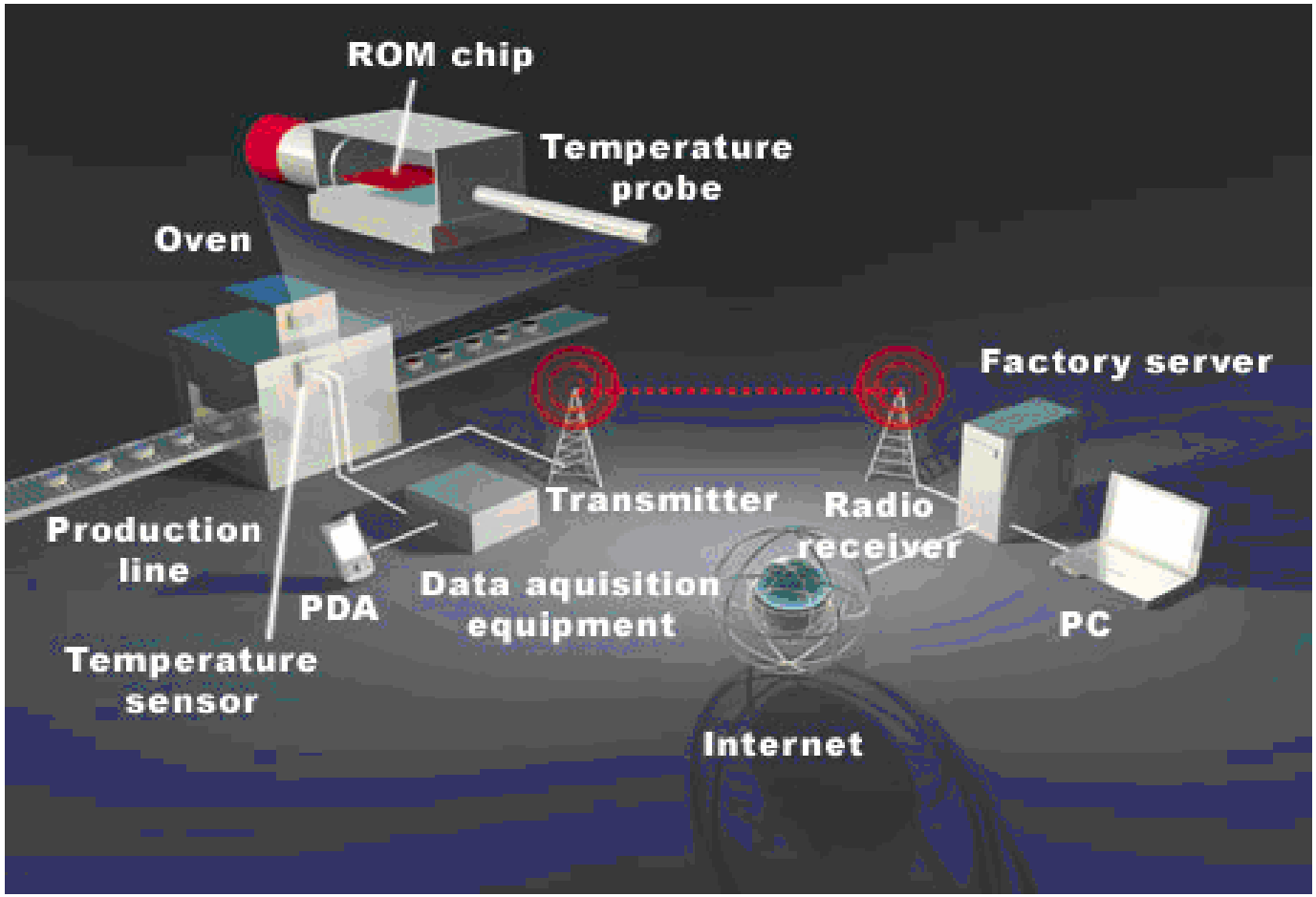


- Biological wanted effects





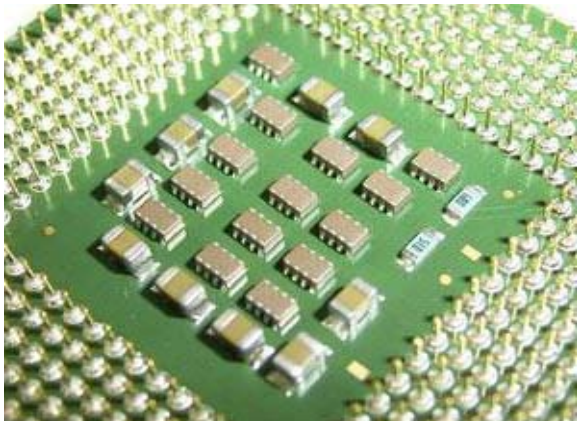
- **Increasingly dense EM environment**
  - **Co-existence: compatibility in complex and dynamically changing environment.**



Semiconductors technology

	2000	2005	2010	2015
Transistor gate length (nm)	130	80	45	25
On-chip clock frequencies (GHz)	1.2	5	15	33
Off-chip frequencies (GHz) High-speed buses	0.7	3	10	29
Equiv. switching edge rate (ps)	455	106	32	11
Supply voltage (V)	1.9	1.1	1.0	0.8

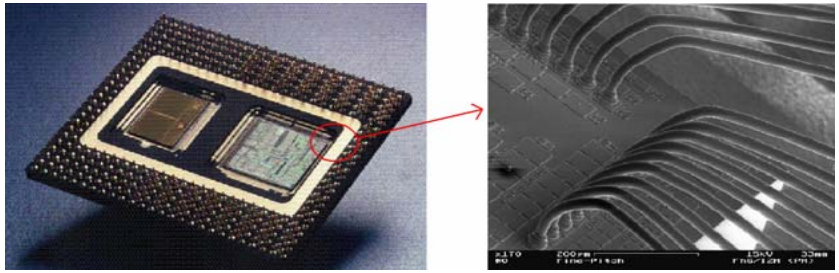
*Source: International Technology Roadmap for Semiconductors 2004



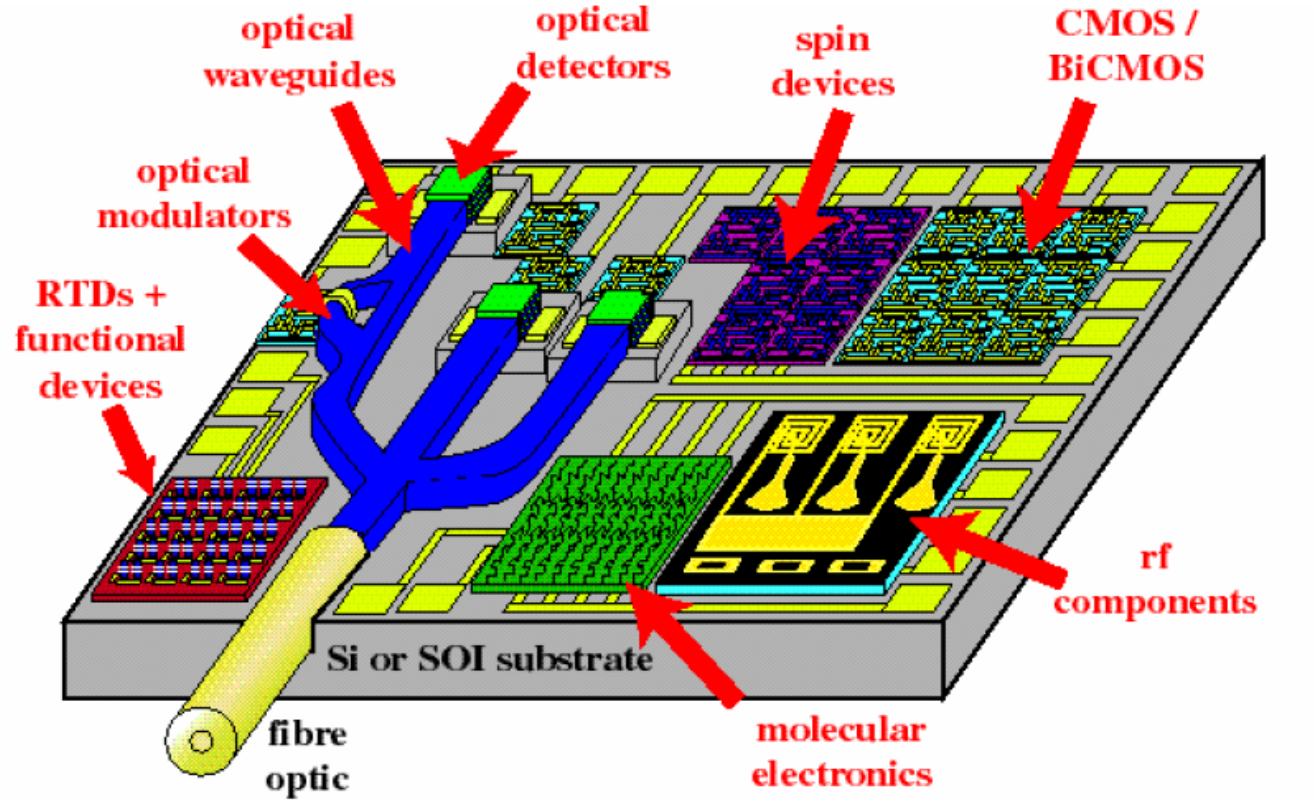
Frequencies
Rise/fall-times
} EMISSION

Supply voltages
Noise margin
} IMMUNITY

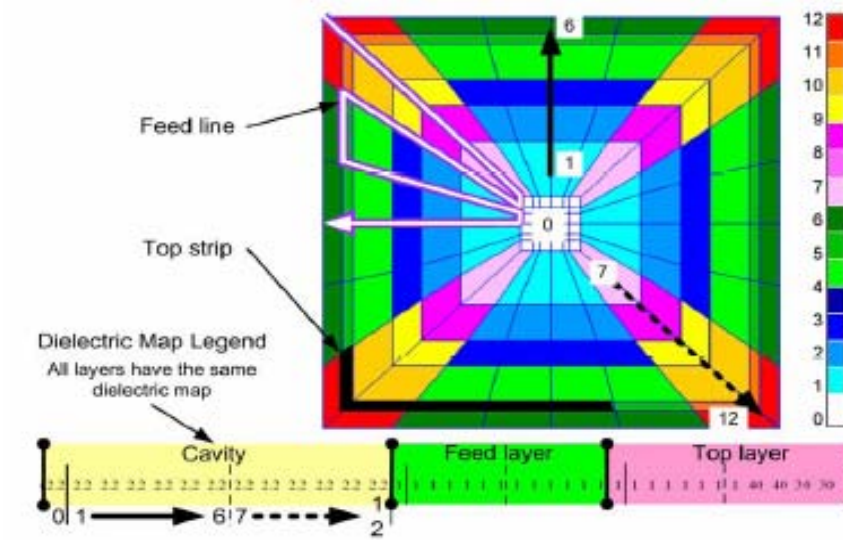
SIGNAL / POWER
INTEGRITY PROBLEMS

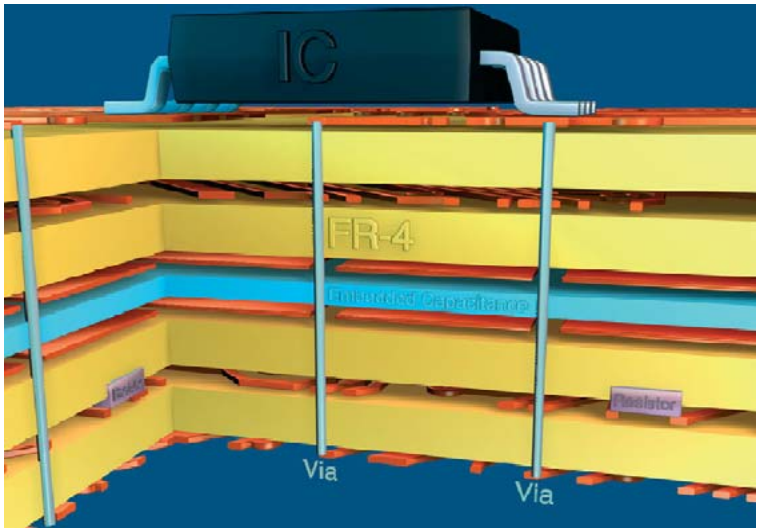


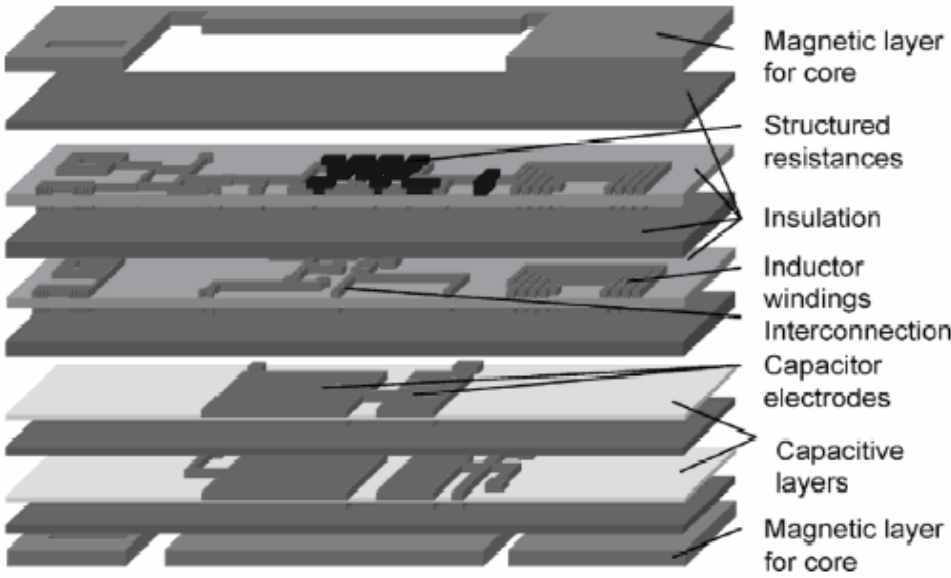
- **Semiconductors technology**
  - **Signal integrity problems will also increase due to the continuing reduction in rise times and the increase in clock frequencies. The question of how to control interference is becoming a key issue in system design.**



- **Innovative materials**
  - New power semiconductors at high temperatures: integrated in direct drive motors
  - Metamaterials to decrease the size of antennas
  - Novel materials to embed passive components



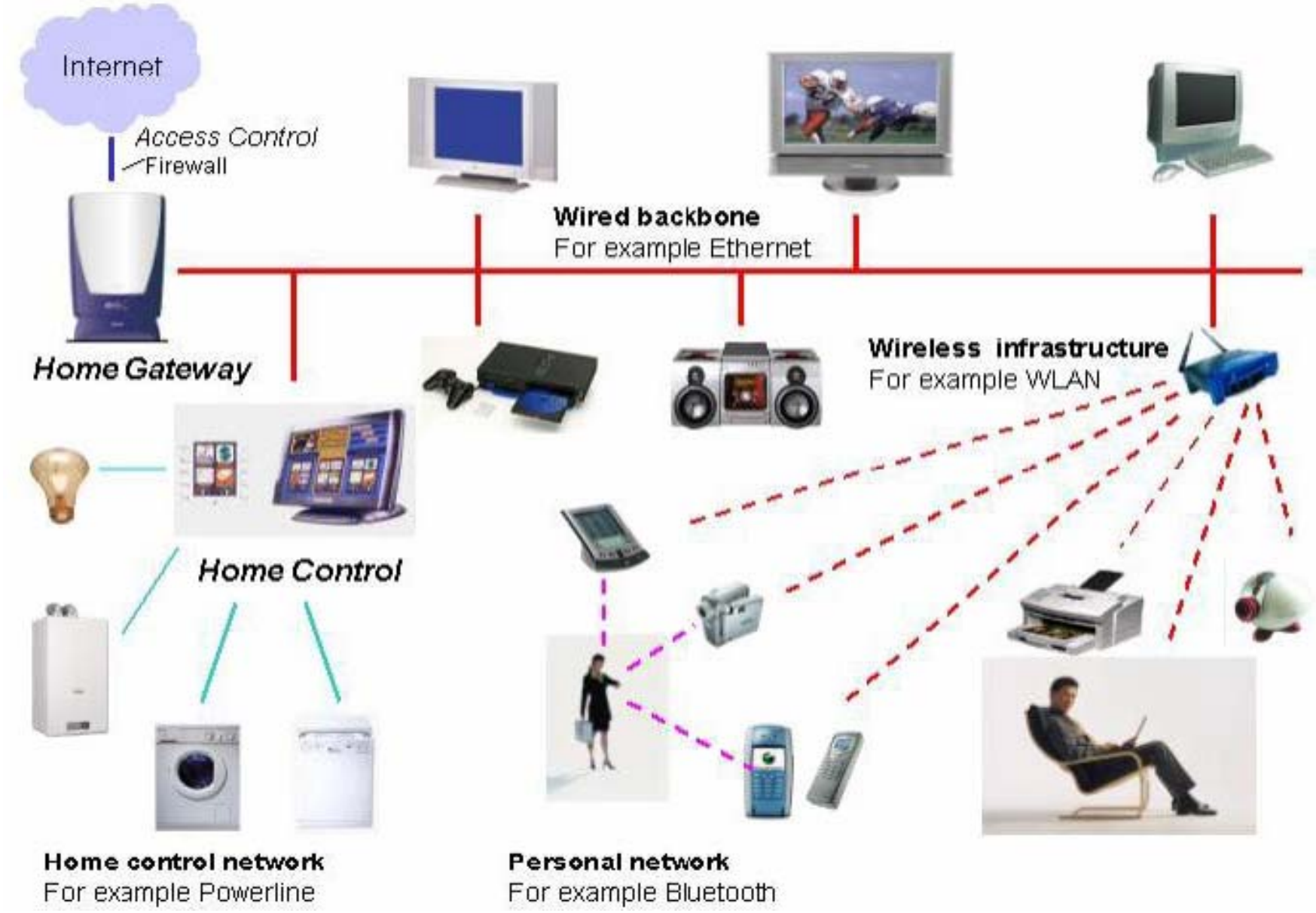




Mobile phone, television, PDA or camera?

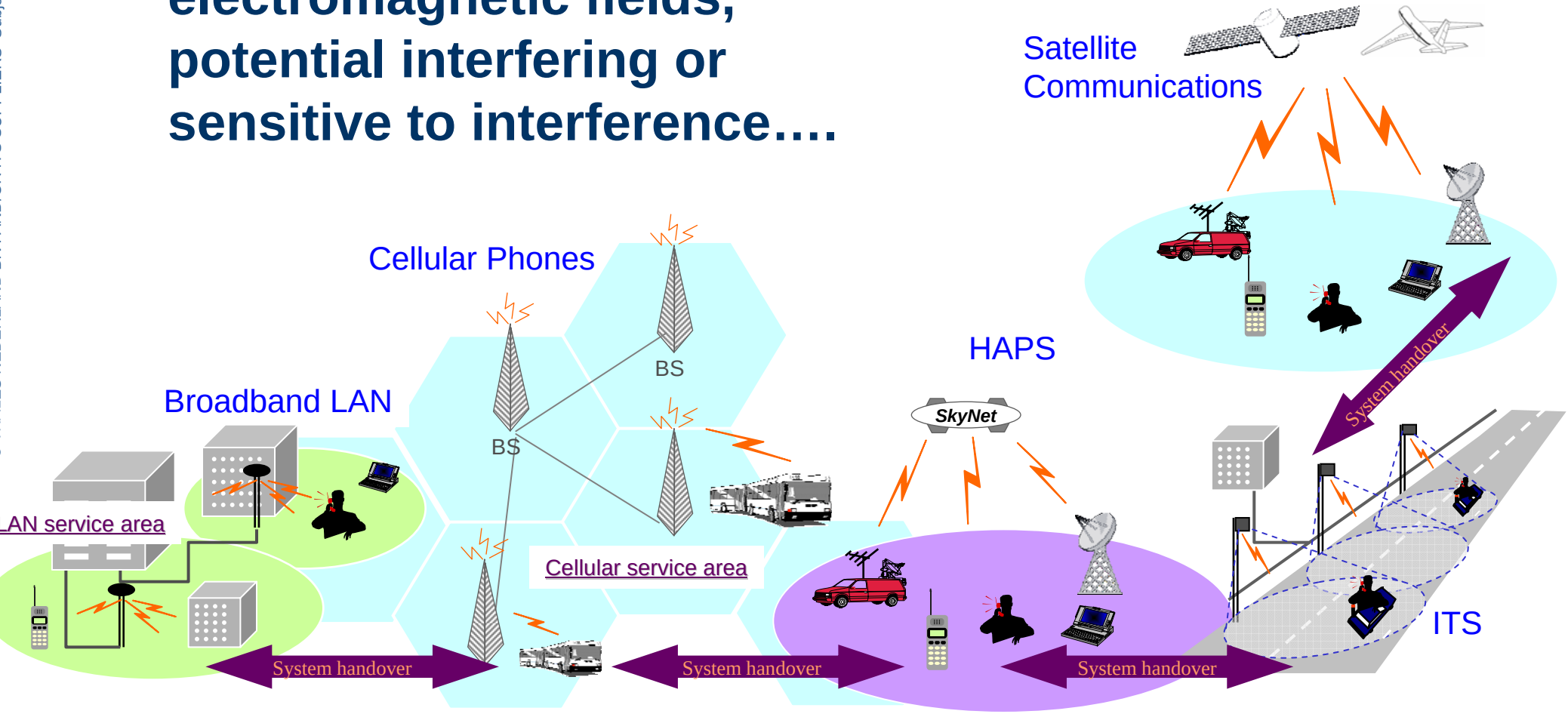
- **EMC standardization**
  - New EMC standards for new products (high clock frequencies, digital modulation techniques and wired & wireless communication devices)
  - Current EMC test methods have their origins in analogue technology and the limits are based on the protection of analogue radio and TV services below 1 GHz.
    Digital radio services have different tolerances to broadband and narrow band interference than analogue radio services.
    Urgent investigation is needed into what the effect of this will be in terms of interference limits and test methods for digital radio/TV products.
    Resolving the digital EMC problem is going to be a major challenge in the coming decade.
  - We need to develop a database of defined protection levels for radio services that can be used as a basis for deriving future EMC limits.

Mix of wired and wireless



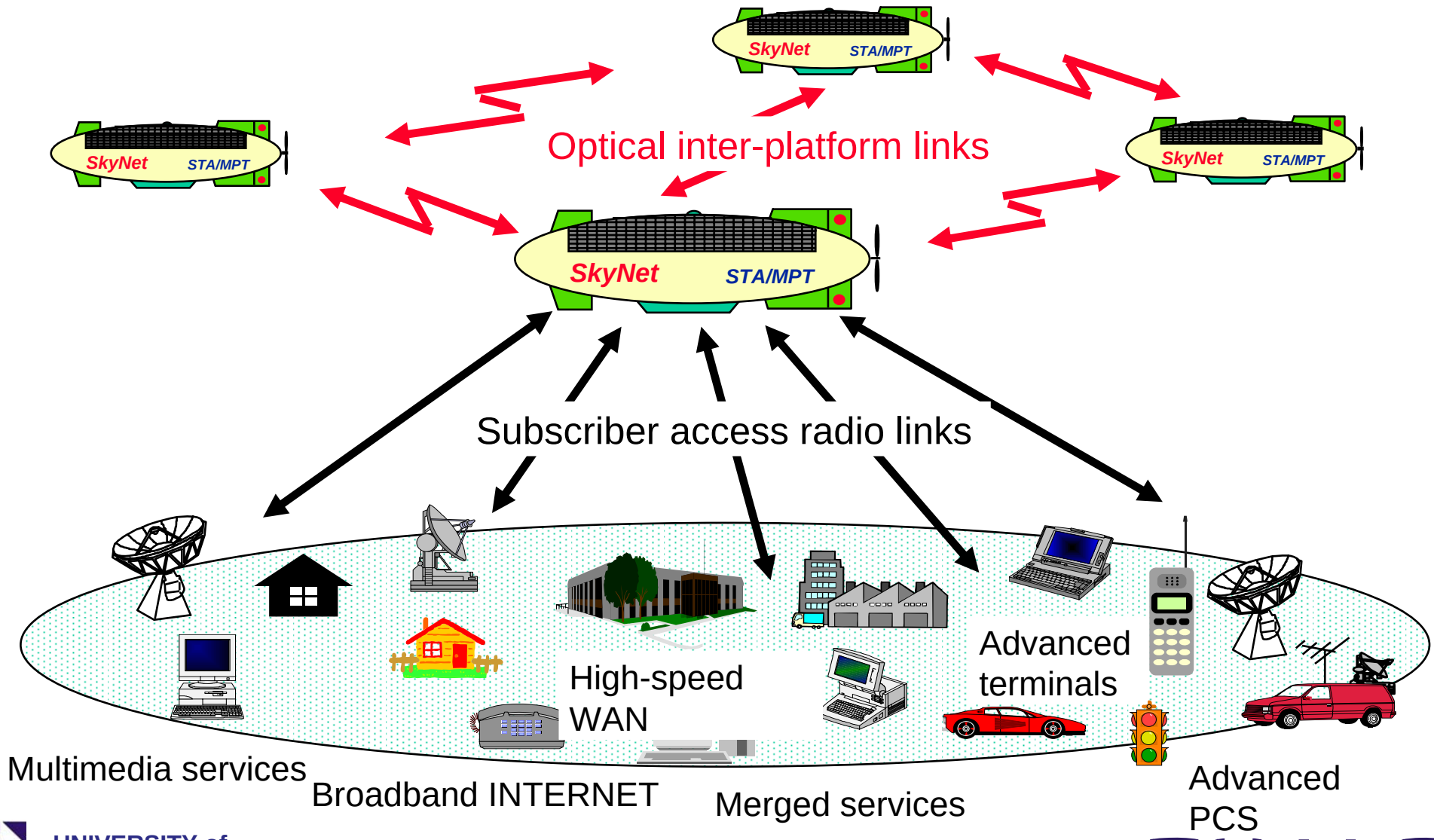
Wired and wireless

Note: all red arrows are electromagnetic fields, potential interfering or sensitive to interference….

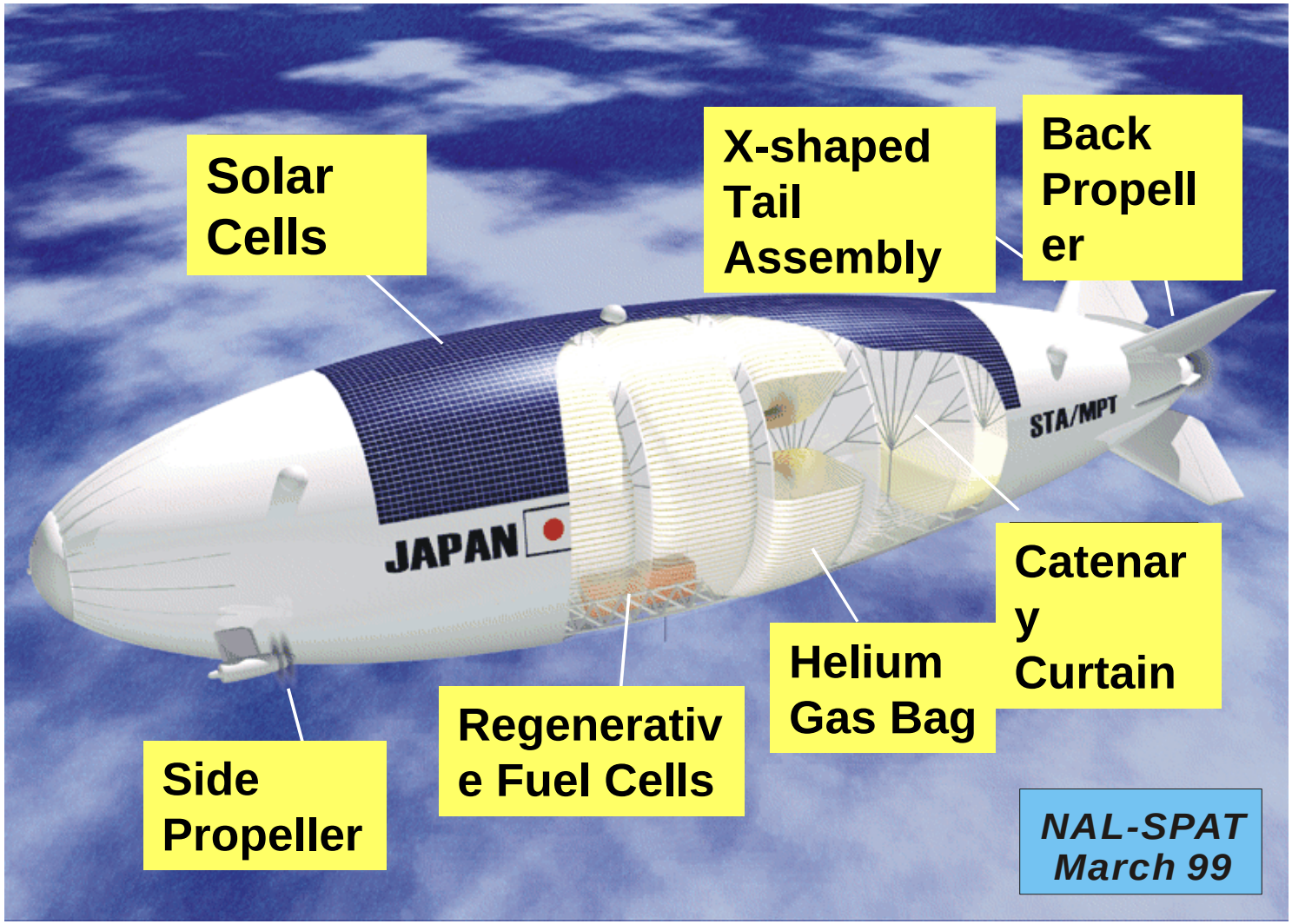


Stratospheric Broad-band Access Network

-Skynet : High speed network using Airship stations-



Stratospheric Platform

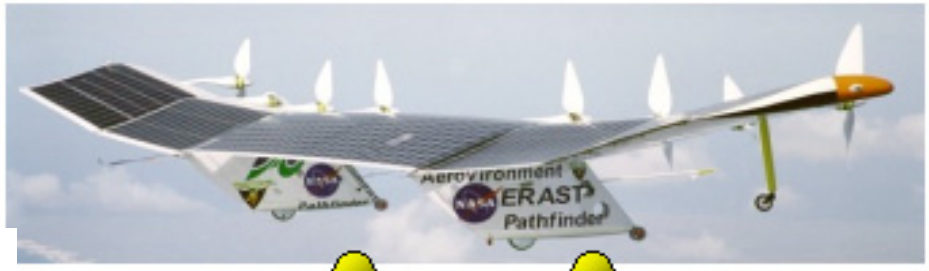


- Unmanned large aircraft which stays stationary in the stratosphere.
- Ideal for radio relay stations (HAPS) and for remote sensing.

HAPS : High Altitude Platform Station

Altitude : 20km, Max.wind : 30m／s

Experiments at 20km altitude (Japan, Hawai)



User terminal

Pod-1(L)

Pod-2(R)

2 GHz

2 GHz

ユーザー端末局

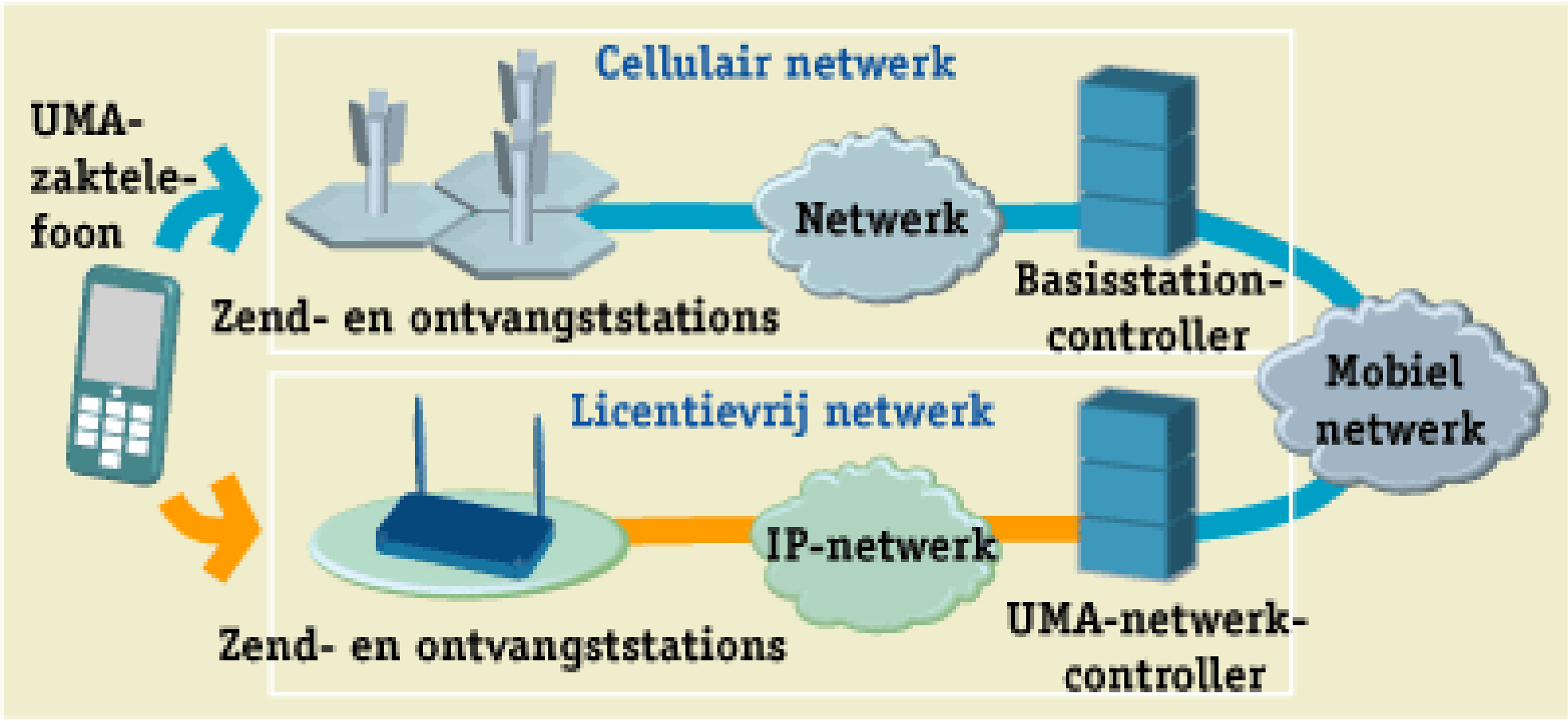
Ground Base station

Mobile phone (DoCoMo FOMA)

Experiments on

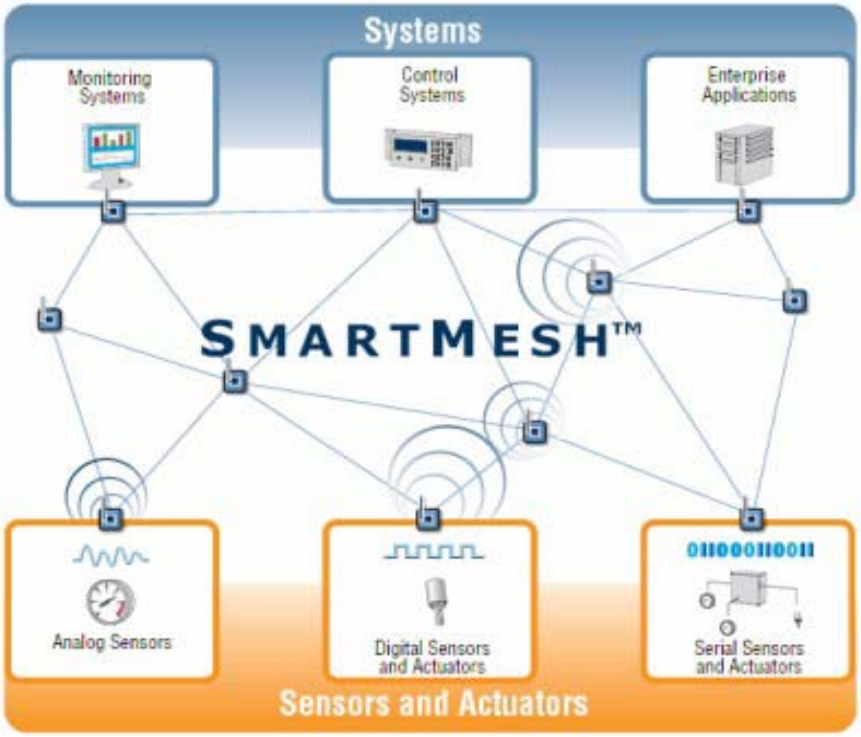
- **Voice (12kbps)**
- **Video (64kbps)**
- **Internet (384kbps)**

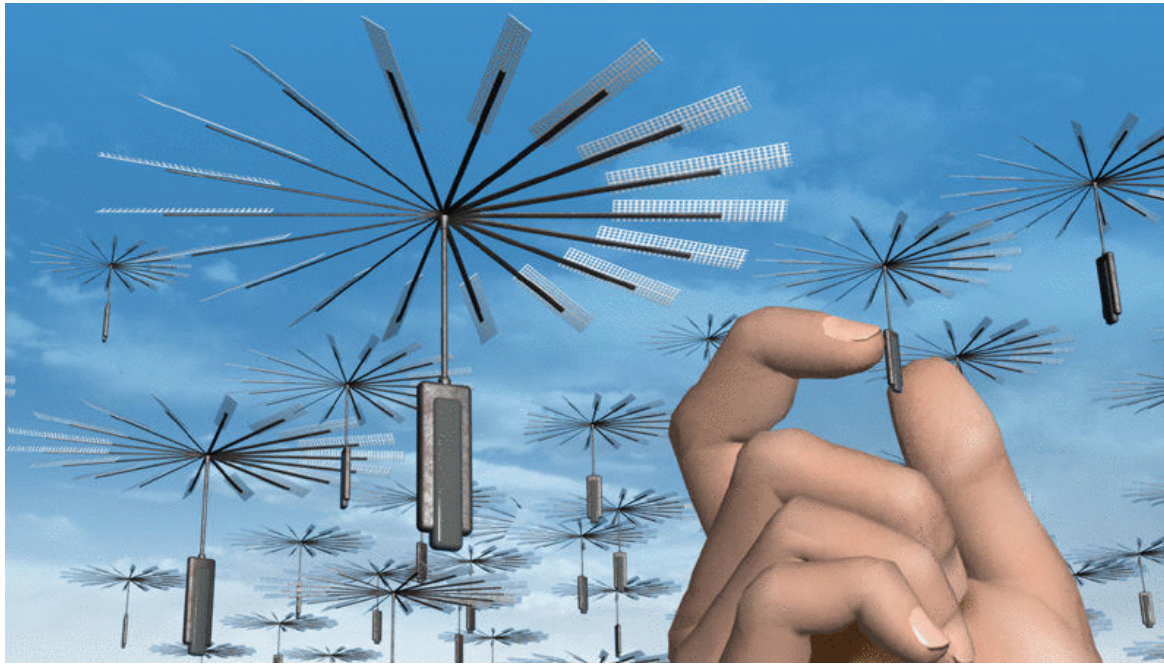
Unlicensed Mobile Access: lower costs



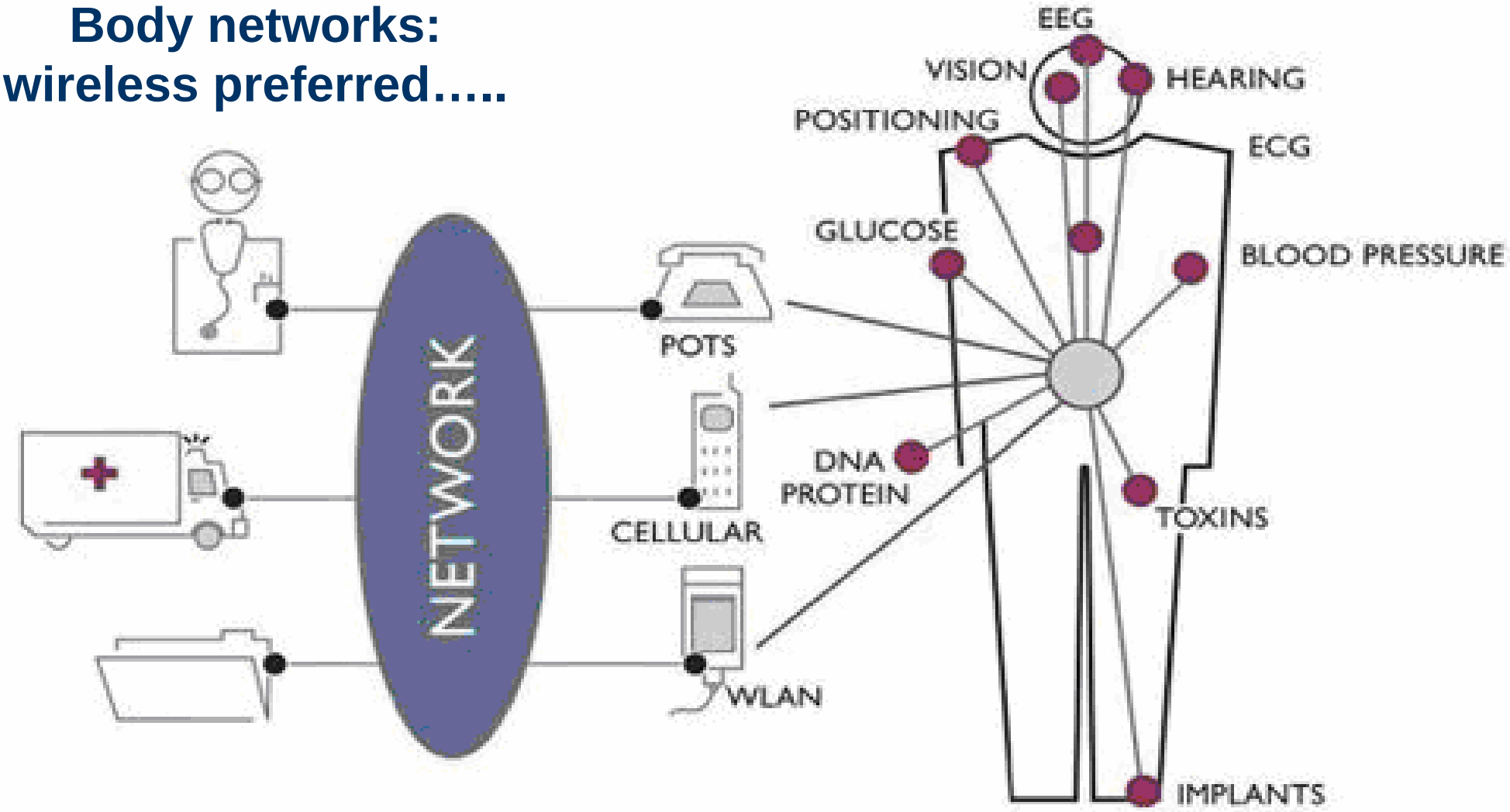
- **Smart Dust**
  - **Future sensor systems (‘smart dust’) will rely on**
    - **wireless systems**
    - **large numbers of highly sensitive,**
    - **low-cost and low-power**

    sensor/actuator pairs.

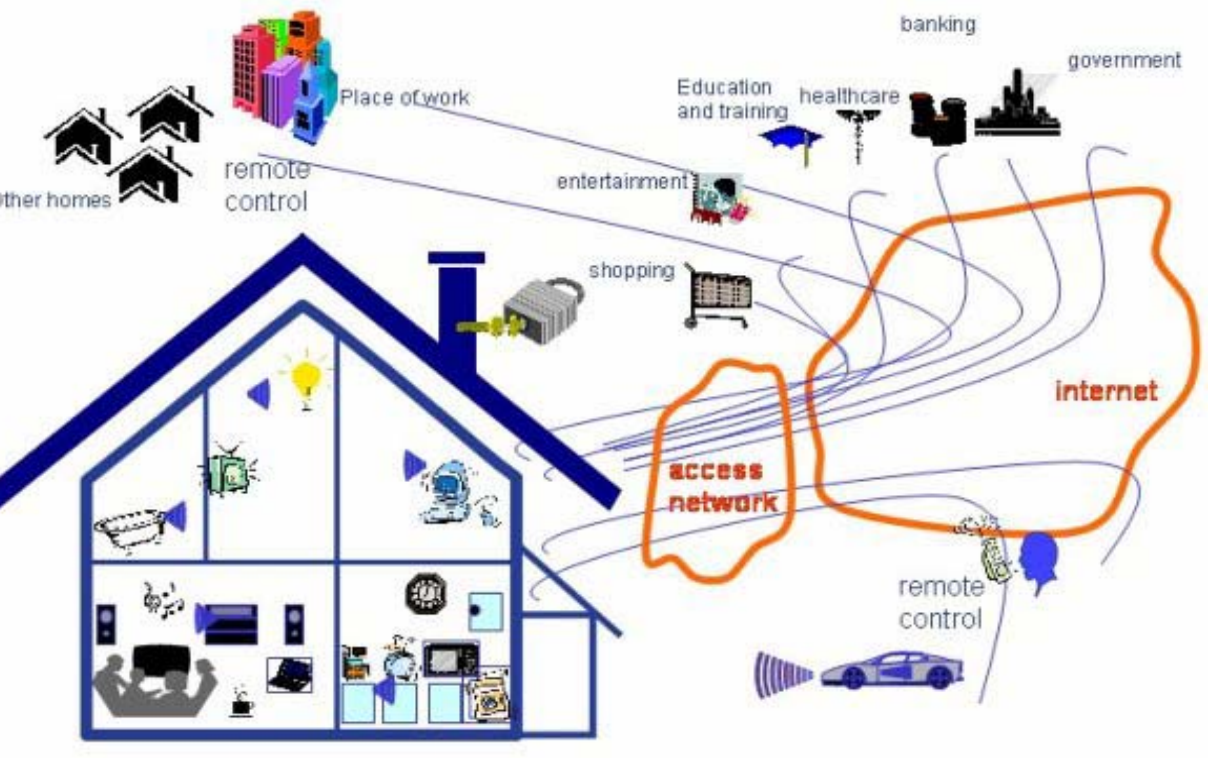


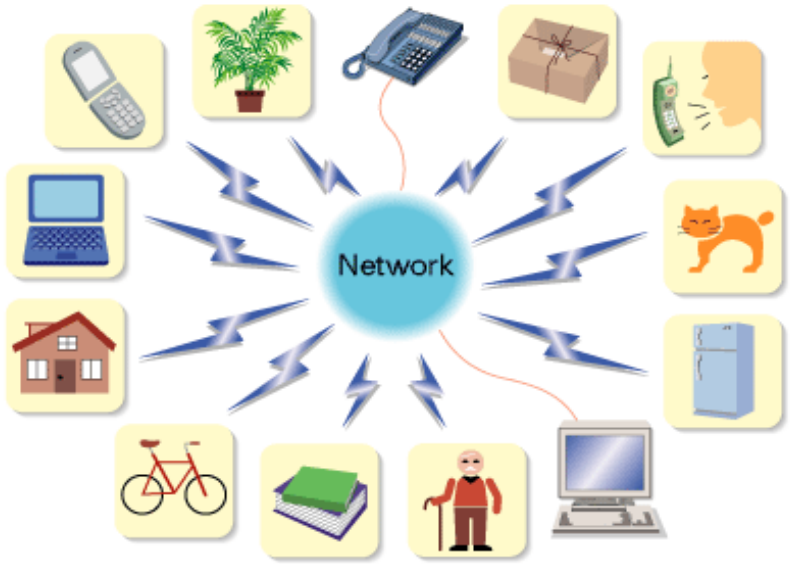


Body networks: wireless preferred…..



Smart communication concepts

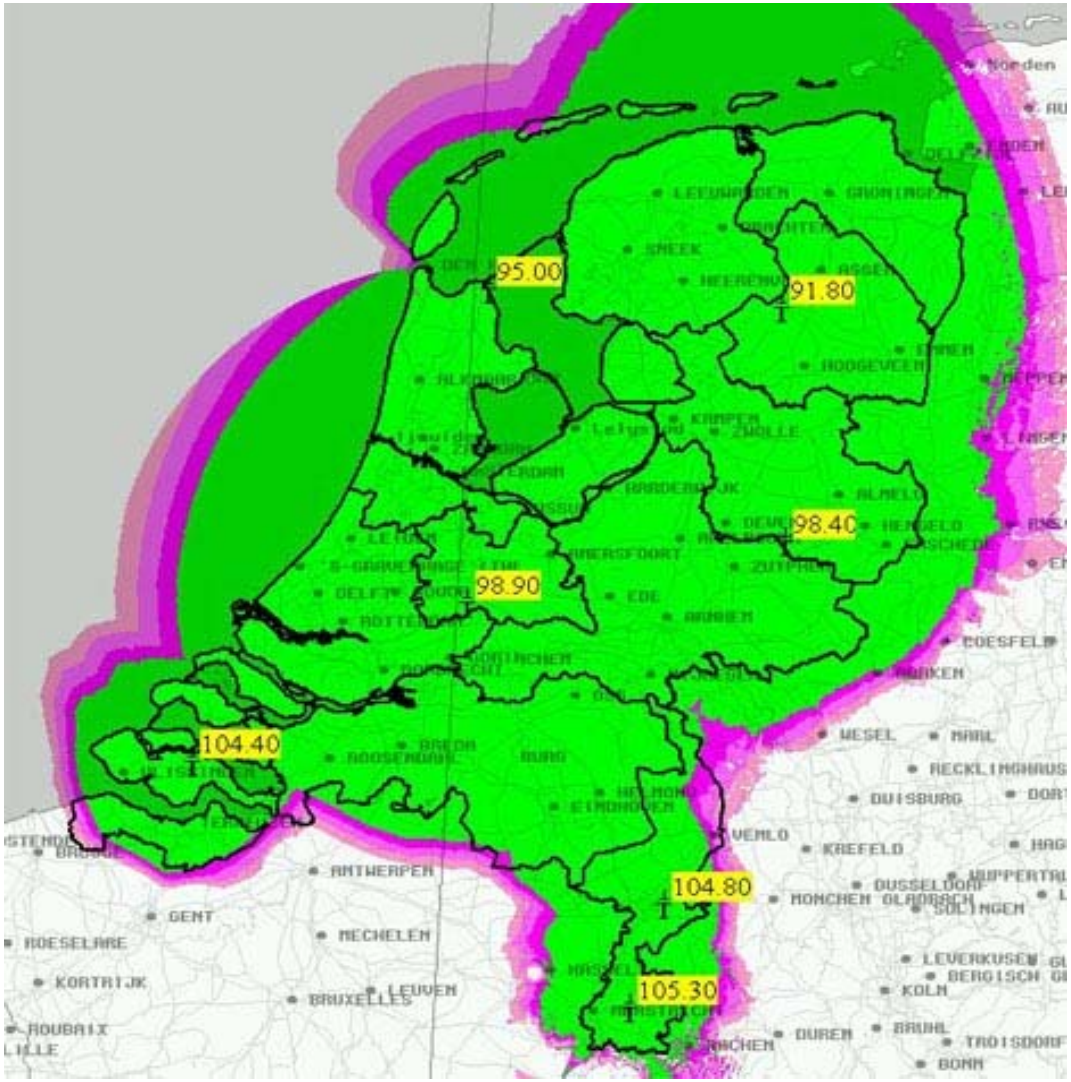




Ubiquitous computing will enable diverse wireless applications, including monitoring of pets and houseplants, operation of appliances, keeping track of books and bicycles, and much more.

effect:
exponential growth of users of the EM spectrum

Electromagnetic spectrum: occupied completely?, 1



coverage Radio 1

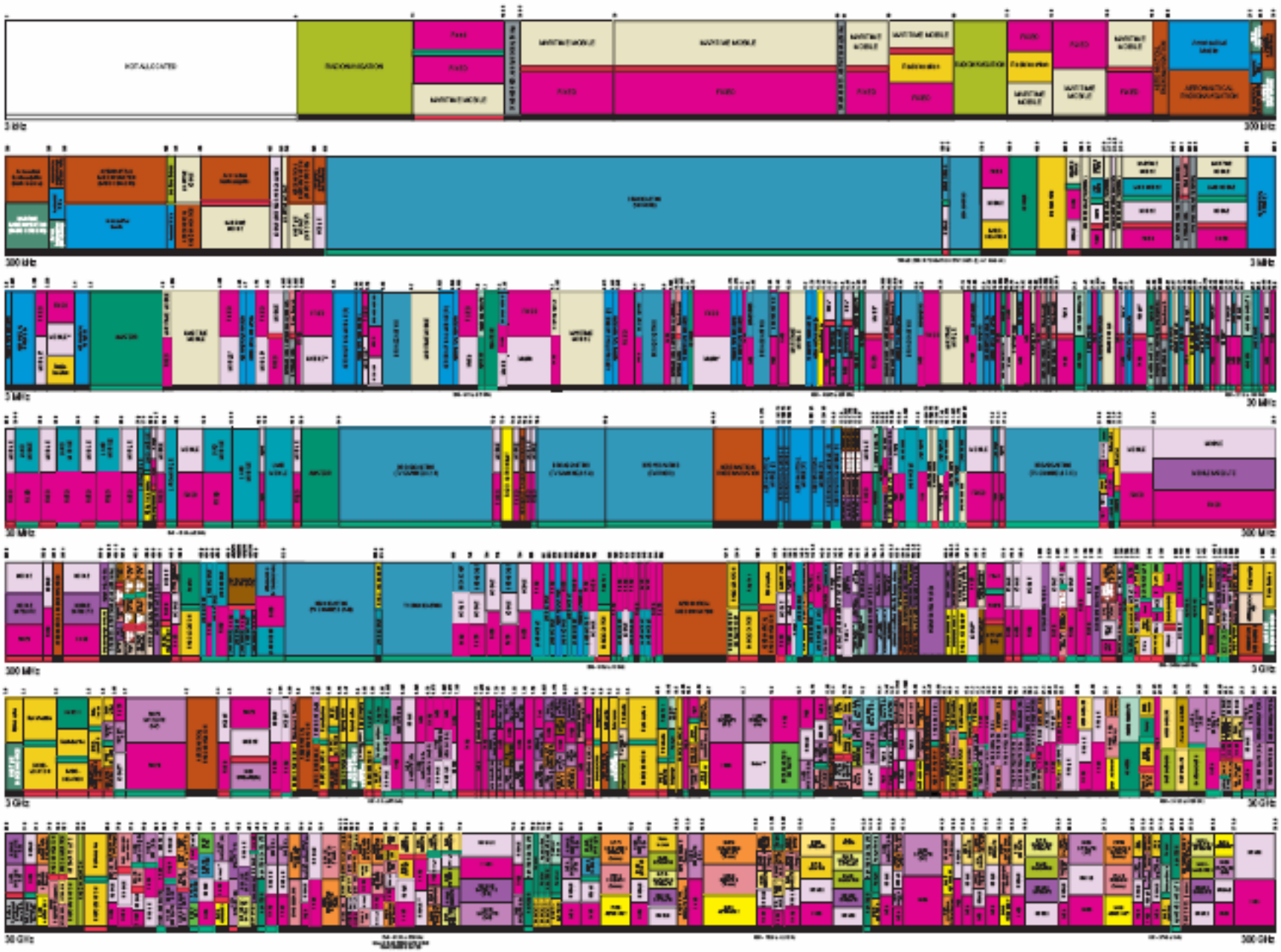
But still interference due to limited quality (selectivity) front-end of radio receivers

And shown before:

WLAN, Bluetooth, microwave ovens: all in same band


Full EM spectrum: looking for best reception

Electromagnetic spectrum: occupied completely?, 2



UNIVERSITY of TWENTE

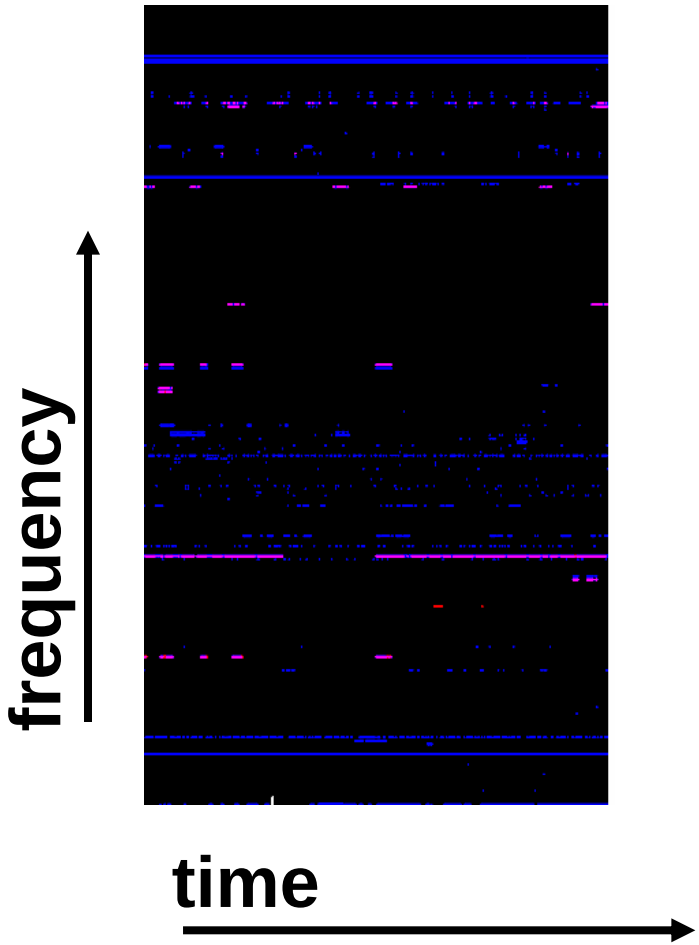
EMC-ESD Praktijkdag 2006
13 juni 2006

THALES

Electromagnetic spectrum: occupied completely?, 3

Large part of the spectrum unused!

- **Only some frequencies, at some places**
- **Only sometimes, some frequencies**

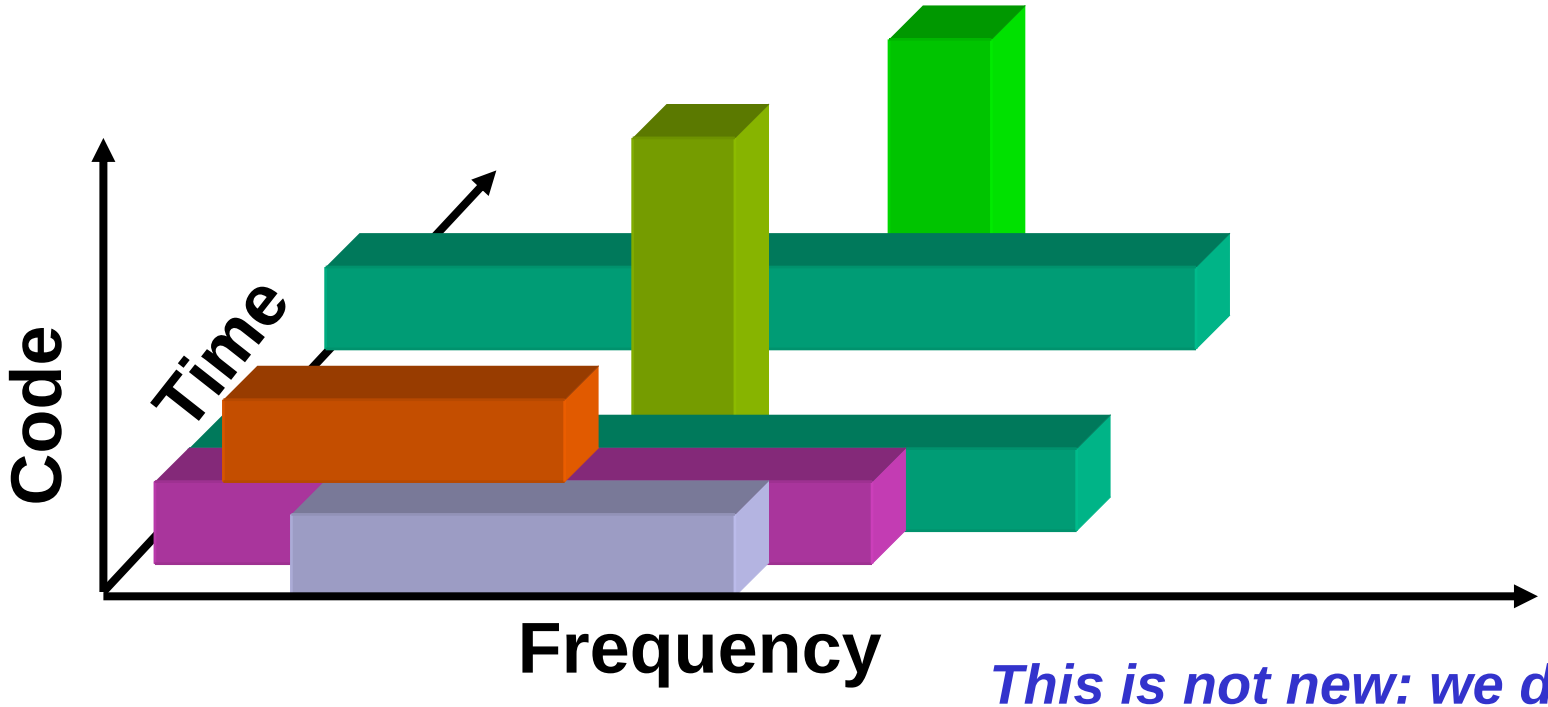


Conventional spectrum trading is not sufficient for capacity needed.

There is a need for Smart Communication concepts

Smart communication concepts, for example

TFMPS: time-frequency-modulation-power-space can be used at the same time together, resulting in an overwhelming openness of our frequency spectrum, compared to the conventional approach of singular Time or Frequency, other domains.



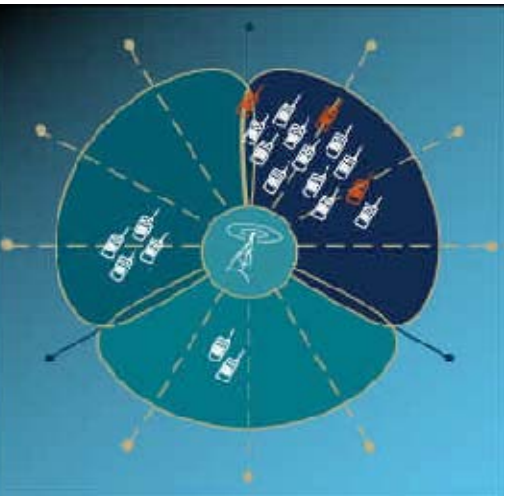
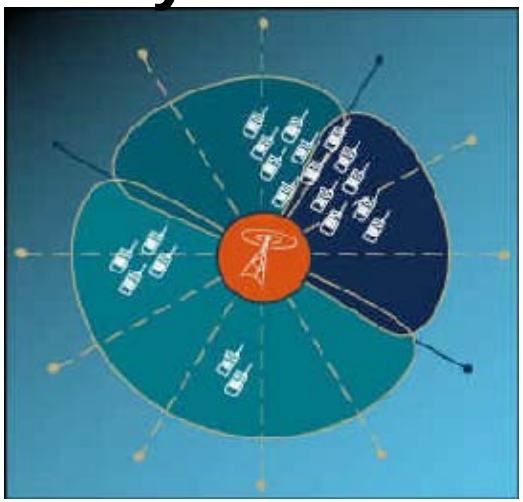
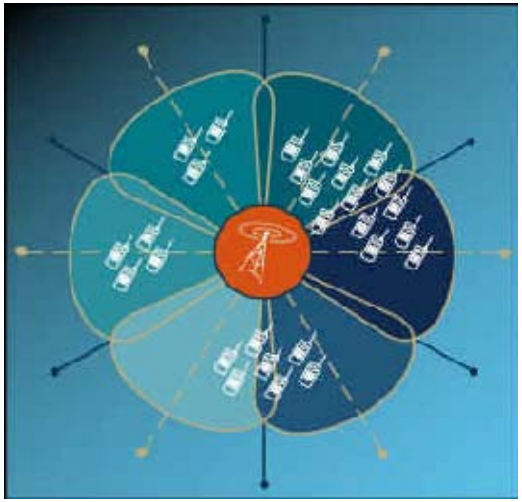
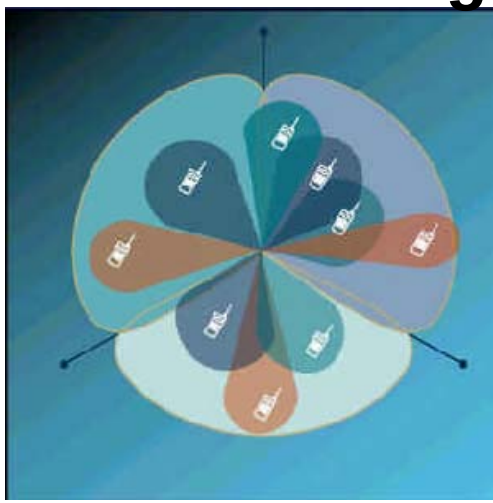
Known:

TDMA
FDMA
CDMA

Singular!

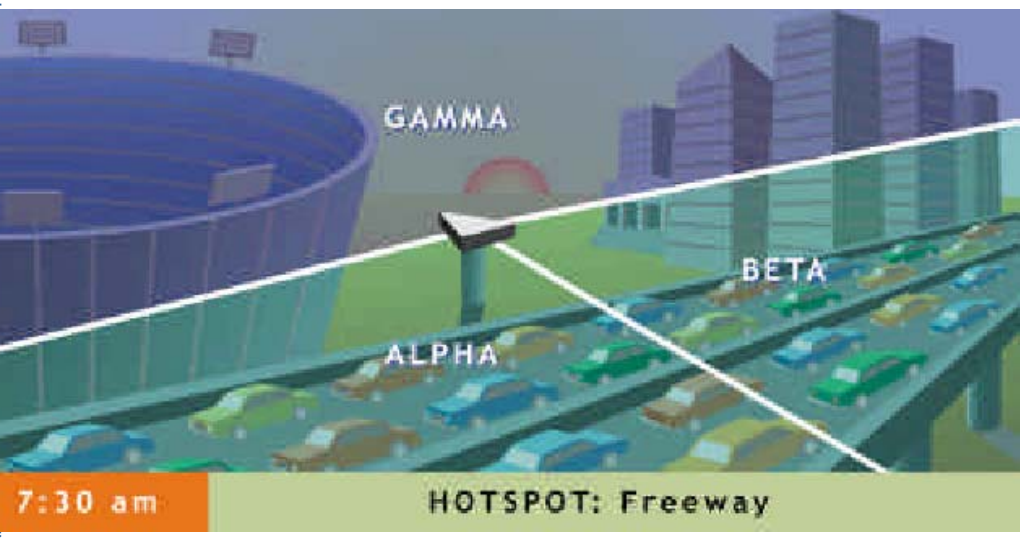
This is not new: we do it for some decades onboard of naval vessels….

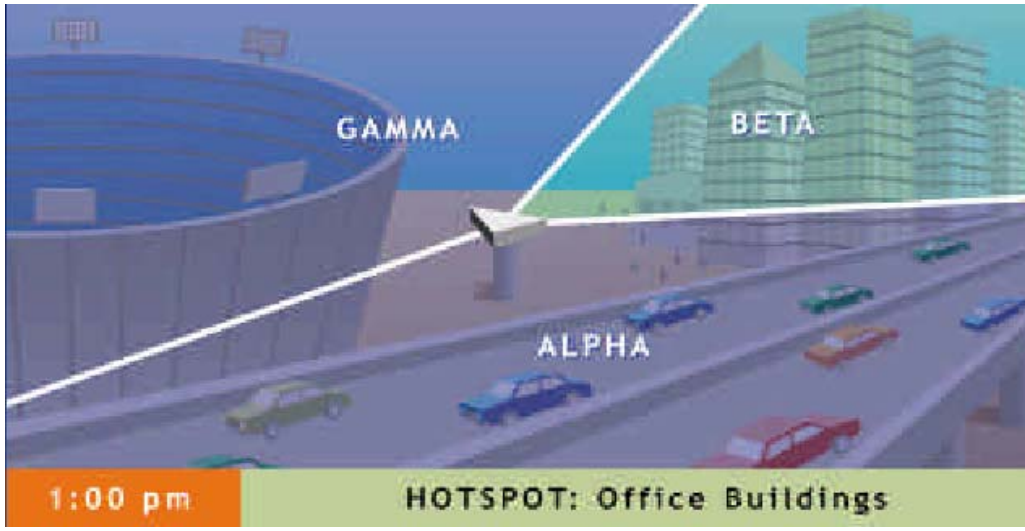
Smart communication concepts:

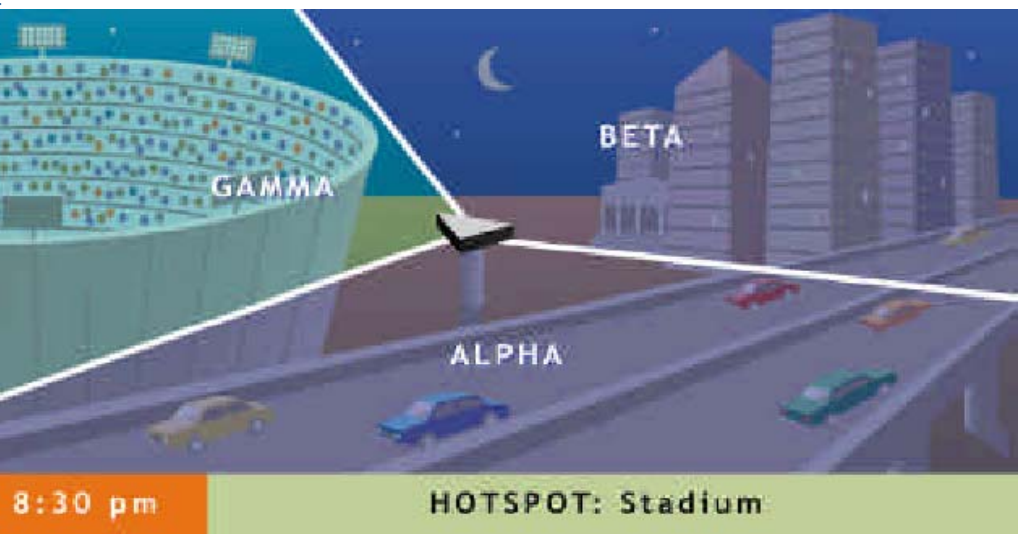
Traditional	Sector synthesis	Flexible sectorization	Adaptive beamforming
			
Unbalanced traffic	**50% increase in capacity**	**90% increase in capacity**	**250% increase in capacity and less interference…**

This is not new: we do it for onboard of naval vessels….

Smart communication concepts, 3







Automatically adjust sector patterns to match traffic conditions conditions

Set pattern changes according to time-of-day rules or

Dynamic, real-time load balancing and performance optimization

and less interference in dedicated areas

Need for more antennas at the same spot

Example: modern car

- Broadcast radio and video (AM, FM, DVB)
- Mobile phone (tri-band: 900, 1800, 1900 MHz, 3G, 4G)
- Positioning and tracking (GPS, satellite)

and and and….

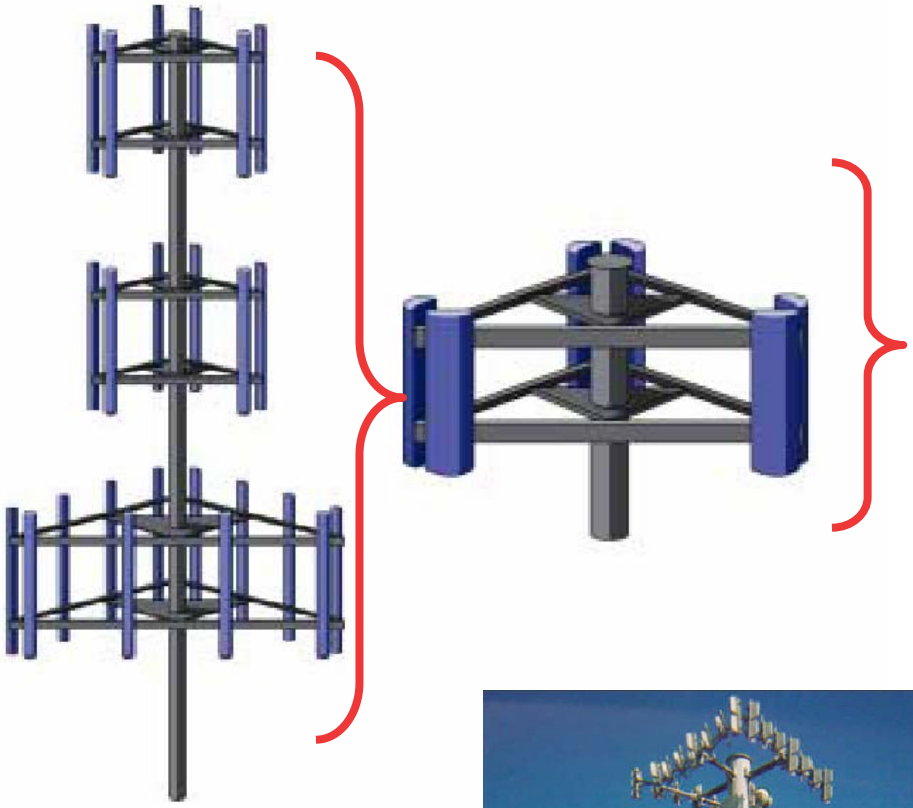
Example:

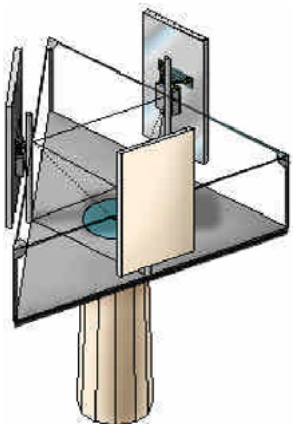
- Rural areas, with only limited number of masts allowed

Need for multiband antennas

Smart communication concepts, 5

Multi-band antennas

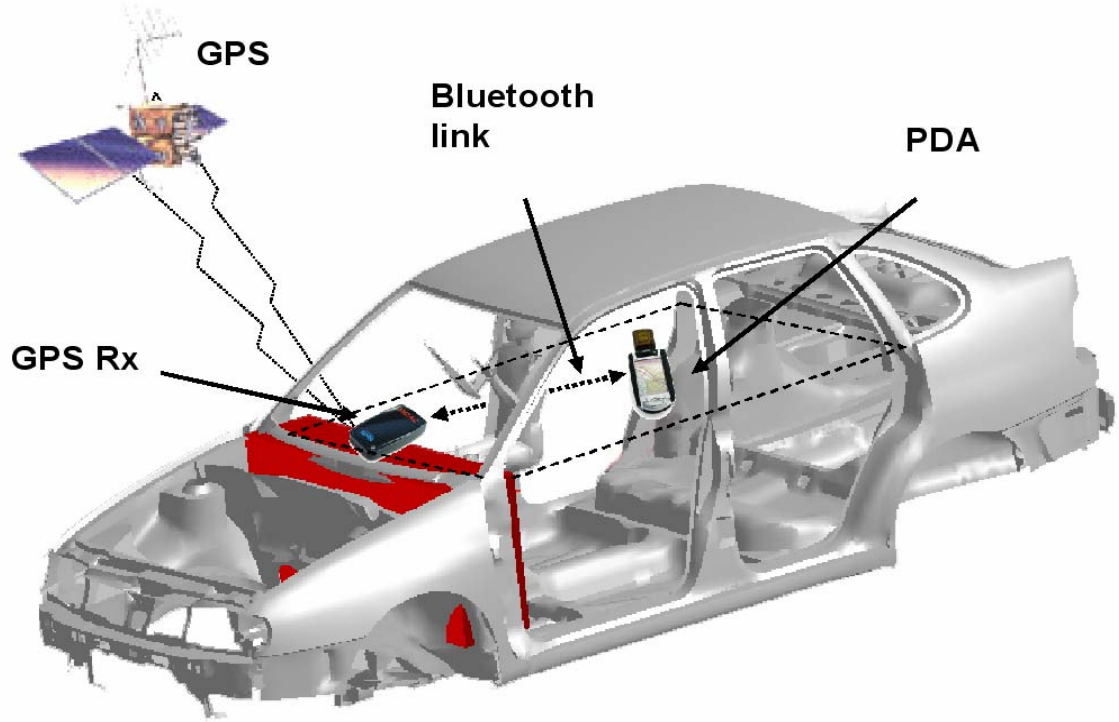




Upcoming issues: multiple reflections, 1

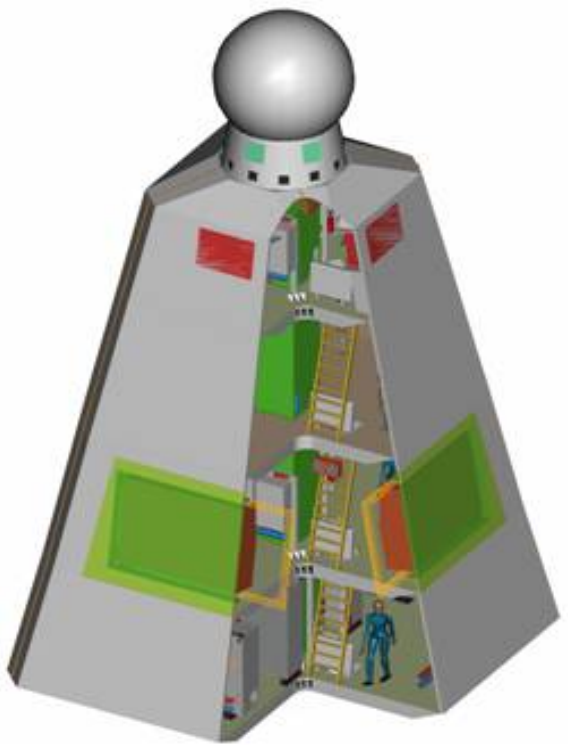
Many environments:

Bus, car, cruise ship



Upcoming issues: multiple reflections, 2

Upcoming issues: multiple reflections, 3



Multiple reflections:

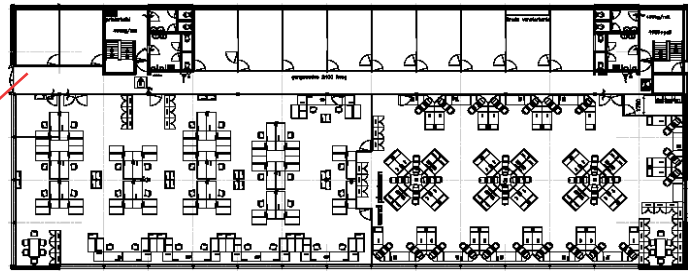
- Propagation influences throughput

(although techniques in mobile phones, Bluetooth etc. are integrated to overcome these disadvantages)

- Interference increases

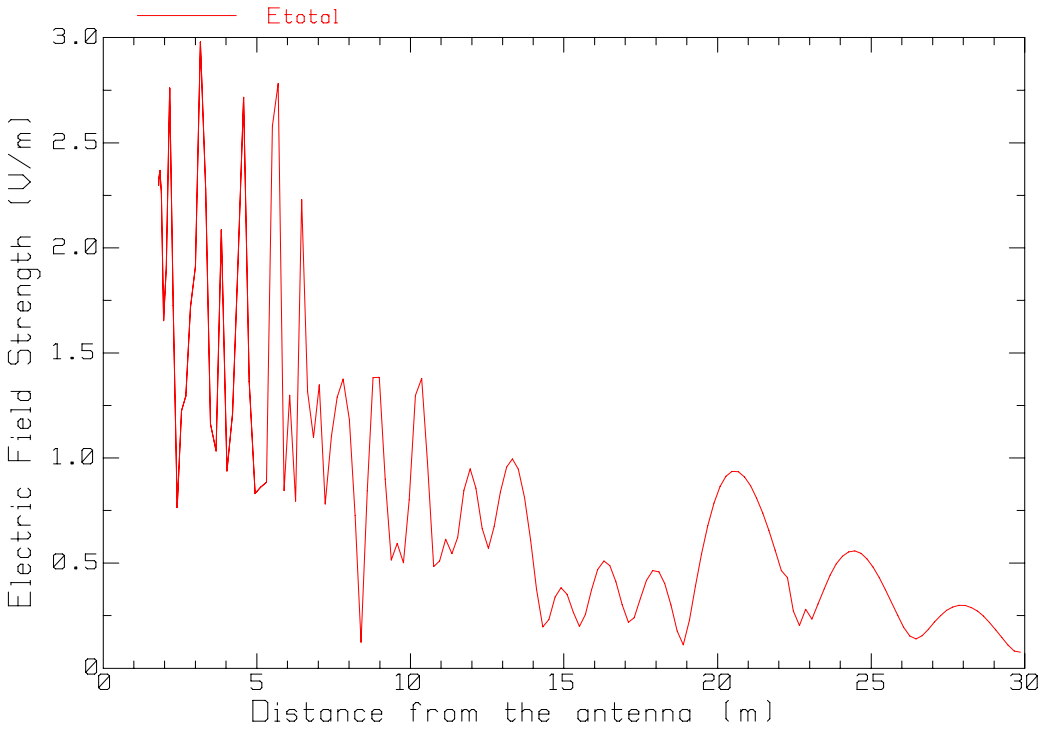
Upcoming issues: multiple reflections, 4

Field distributions: hallway



Electrical field strength as a function of the distance to the antenna across the entire hallway

and measurements



Still important issue: power consumption

Synchronous systems

- change state all at once, when a clock signal changes state.

Asynchronous systems

- propagate changes whenever inputs change.

Disadvantage of a synchronous system is the power consumption, which is nearly independent of activity.

For wireless (portable) devices we need low power consumption, so asynchronous systems will increase.

But:

Asynchronous systems are very unstable, hard to design and very sensitive to EMI, including ESD…….

EMI research challenges, 1

- Materials / meta-materials
  - Innovative materials for EMC applications
  - Incl. nanotechnology, shielding, and filtering
- Signal- & Power Integrity
- EMC impact of new technologies
  - Communication technologies
  - Automotive hybrid drives
  - Power electronics drives
  - Sensor technologies
- Interconnects
  - Wireless (antenna's, co-existence, …)
  - Wired (PLC, High-Speed buses, …)
- EMC of semiconductor devices
- Transients protection (ESD, lightning)

EMI research challenges, 2

- New test methods
  - Test methods above 1 GHz: RVC, TEM,
  - Statistical vs. deterministic data evaluation
  - Diagnostic methods
  - IC/module testing for system characterization
  - Methodologies for translation of EMC requirements between various (sub)-system levels
  - In-situ testing (large systems)
  - Measurement / compliance uncertainty
  - Fast emission measurements in time domain
- Unification of standards
  - Multimedia, Defense, Automotive, Aerospace, Electro-medical devices
- EM spectrum control
  - Intentional and unintentional radiators

EMI research challenges, 3

- EMF: Human exposure to EM fields
  - Exposure assessment and mitigation tech-niques
- Product Safety (EMC for functional safety), Risk based EMC
- IEMI: Intentional Electromagnetic Interference
- New computational techniques
  - Hybrid techniques for multi-scale problems (FDTD, TLM, PO, …)
  - Multidisciplinary techniques for concurrent engineering (EMC, thermal, mechanical, …)
- Modelling of novel materials
- Non-deterministic modelling
- Expert systems / design tools
  - For components, board, cables/connectors, and systems
  - EMC/SI/PI verification, analysis, synthesis
- Certification by simulation
- EM dosimetry

The future is bright

But many EMC and ESD problems and risks to solve….

Brain-implants

Further reading

- Frank Leferink, Verstoorde technologie: een stralende toekomst, Inaugural Lecture University Twente, 30 october 2003
- Christian Verholt, Cenelec, Keynote lecture, European EMC 2002 Symposium, Sorrento
- Peter Kerry, EMC Standards – Quo Vadis, IEEE EMC Istanbul 2003
- Mike Marcus, EMC Paints the Lane Markings on the Wireless Information Highway, Keynote speech EMC Zurich 2005
- Todd Hubing, Impact of EMC on American Industry, Keynote speech during the opening of the European EMC Symposium, 2002.
- Jim McCanny, No, Signal Integrity is not a solved problem, EEdesign, 24 Jan 2003
- The international technology roadmap for electronic interconnections, 2002/2003, Institute of Interconnecting and Packaging Electronic Circuits (IPC)
- MEDEA+, Europe to become a leader in System Innovation on Silicon for the e-economy, White Book, 2000
- Volpe GPS Vulnerability Report, Recommendations and FAA response, 10 sept. 200
- Robert W. Lucky, The precious radio spectrum, IEEE Spectrum, sept. 2001, pag. 90
- Dick Groot Boerle, Frank B.J. Leferink, The Jammed Wheelchair: a case study of EM and functional safety, EMC Society Newsletter, Fall 2004, pag. 61-65
- W.-J. van der Wurff, L. Duerink, H. Schurer, F.B.J. Leferink, W.C. van Etten, Interference of WLAN and Bluetooth in EM-hostile Environments, EMC Europe 2004
- Strategic Research Agenda's from eMobility, ARTEMIS, NEM: www.cordis.lu/technology-platform