UNIVERSITAT DE BARCELONA

Wireless Biodevices and Systems

Department of Electronics and Biomedical Engineering

Radiofrequency Group

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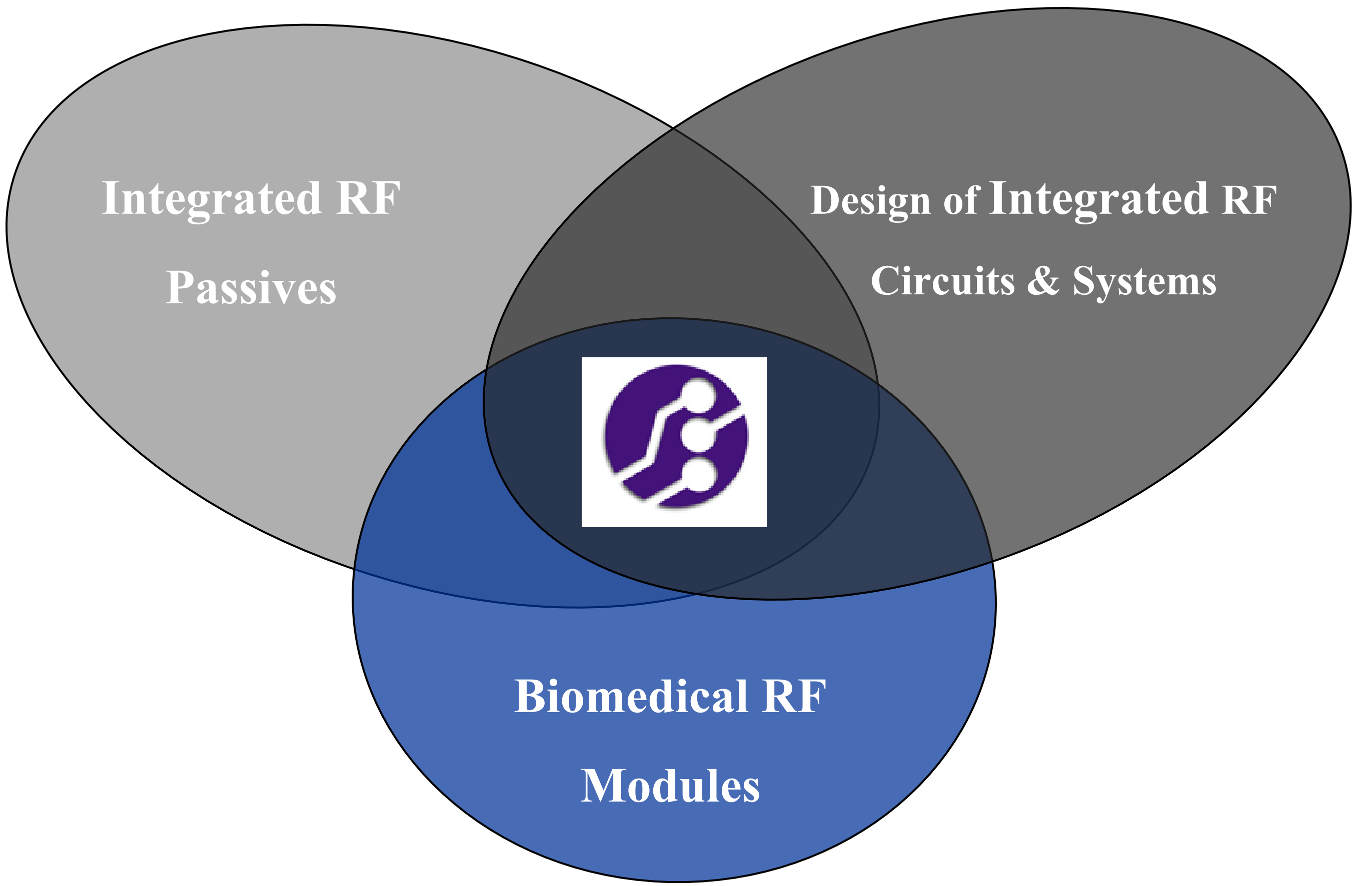
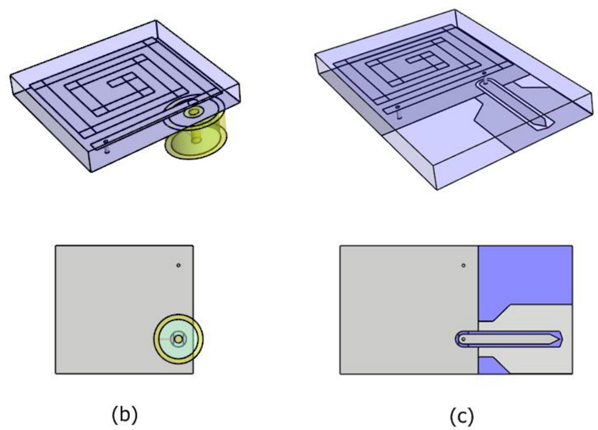
The Group

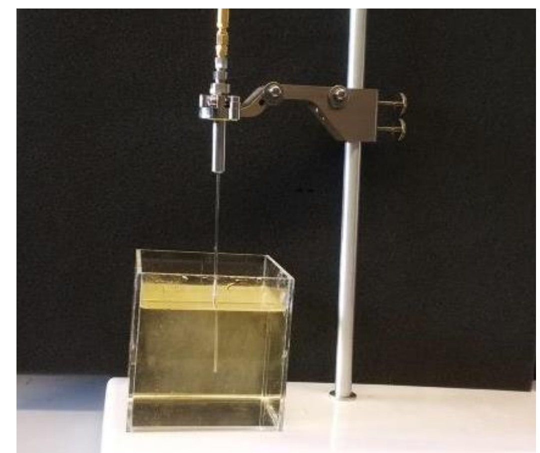
GRAF
Grup de Radio-Freqüència

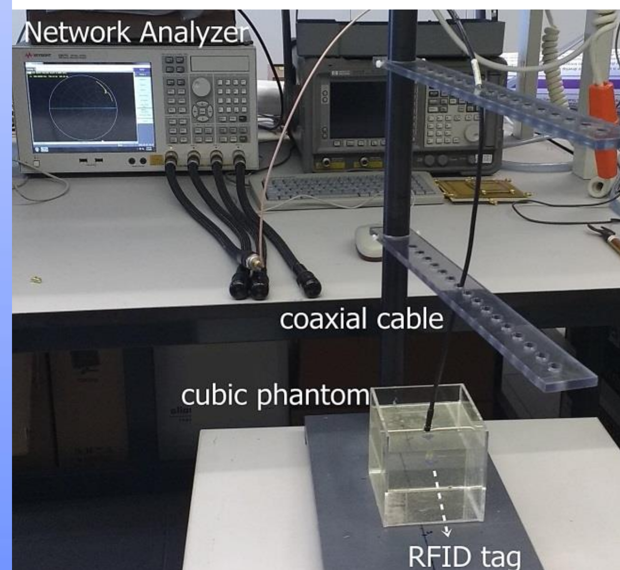


My Research

Antenna design for biomedical applications and electromagnetic propagation-related issues.







Today

no wires

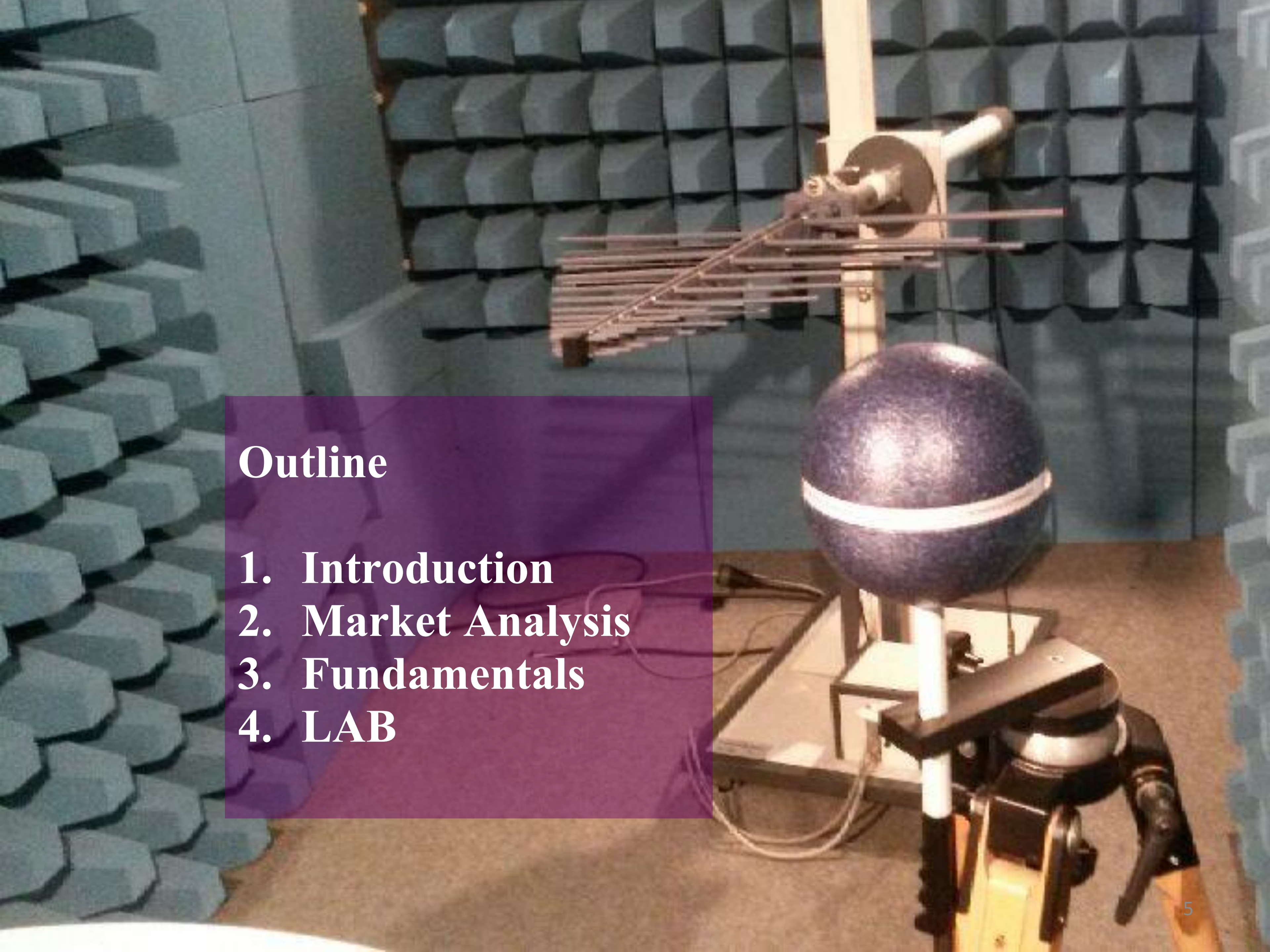
sending data

several devices

Wireless Biodevices and Systems

device constructed from biological components

device constructed for biomedical applications

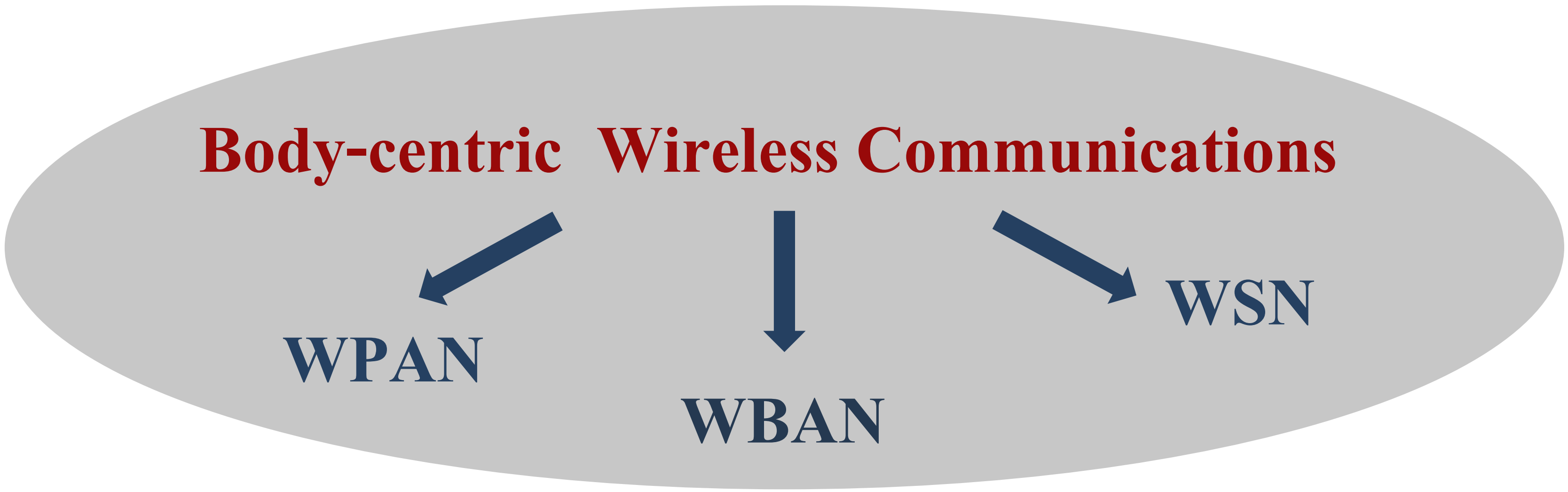


Outline

1. Introduction
2. Market Analysis
3. Fundamentals
4. LAB

1. Introduction

Body-centric wireless communications refer to human networking with the use of wearable and implantable wireless devices.



It is a subject area combining Wireless Body Area Networks (WBANs), Wireless Sensor Networks (WSNs) and Wireless Personal Area Networks (WPANs).

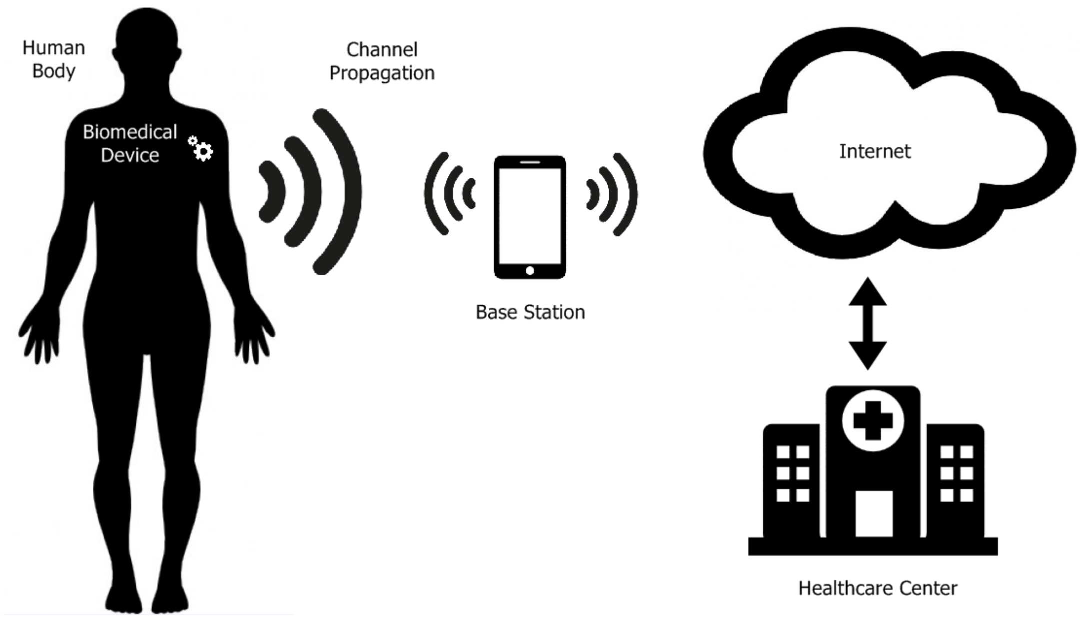
Biotelemetry

https://www.youtube.com/watch?v=_2-csvrh8UM

1. Introduction

Wireless **biotelemetry** allows minimally invasive monitoring of physiological parameters, improving the patient's comfort and care and drastically reducing hospital costs. These advantages will be particularly welcome in the future healthcare scenarios based on **P4 medicine**, especially in view of the current demographic shifts towards more elderly populations and the economic impact that this development is bound to have.

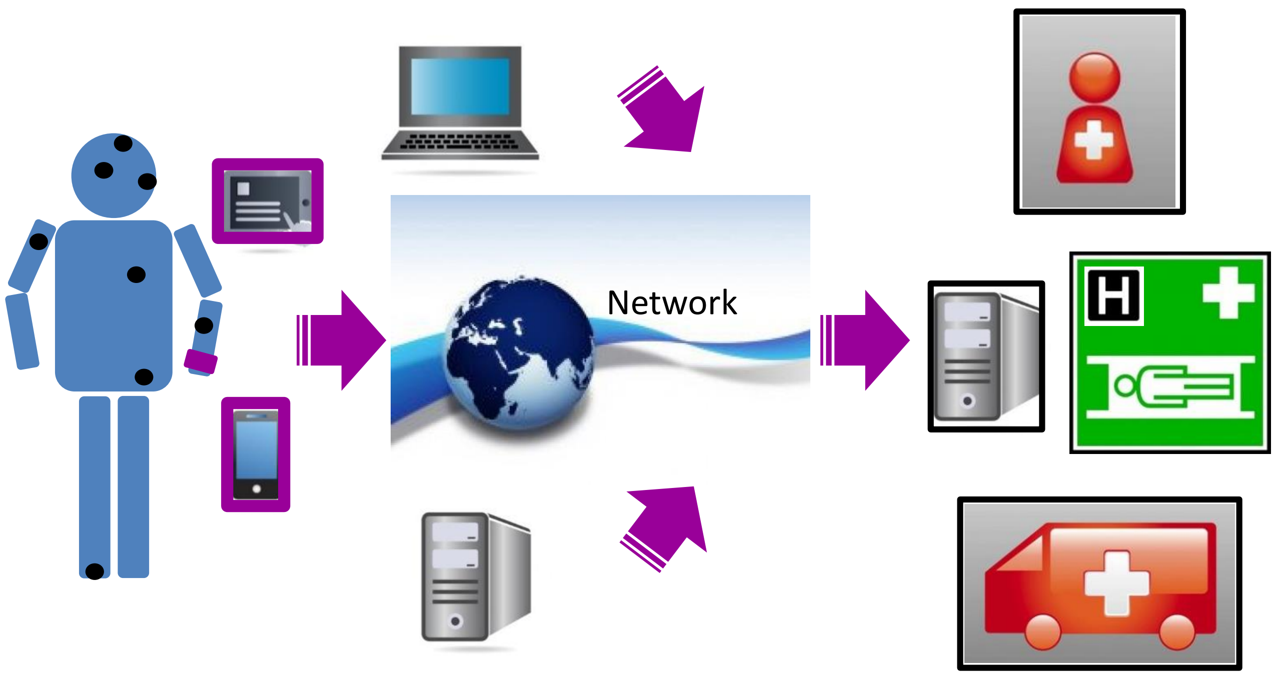
P4 medicine (the four "p"s stand for "Predictive, Preventive, Personalized and Participatory") has evolved rapidly over the last decade and represents a revolutionary new medical paradigm which places the individual patient at the center of healthcare.



1. Introduction

On-body or wearable devices are already present in our everyday life. Smart watches and wristbands with sensing capabilities, for instance, are a reality today. New trends in wearable devices will lead to the blossoming of other types of product, such as headwear or eyewear devices for virtual or augmented reality, smart footwear and bodywear for sport and fitness, and so on.

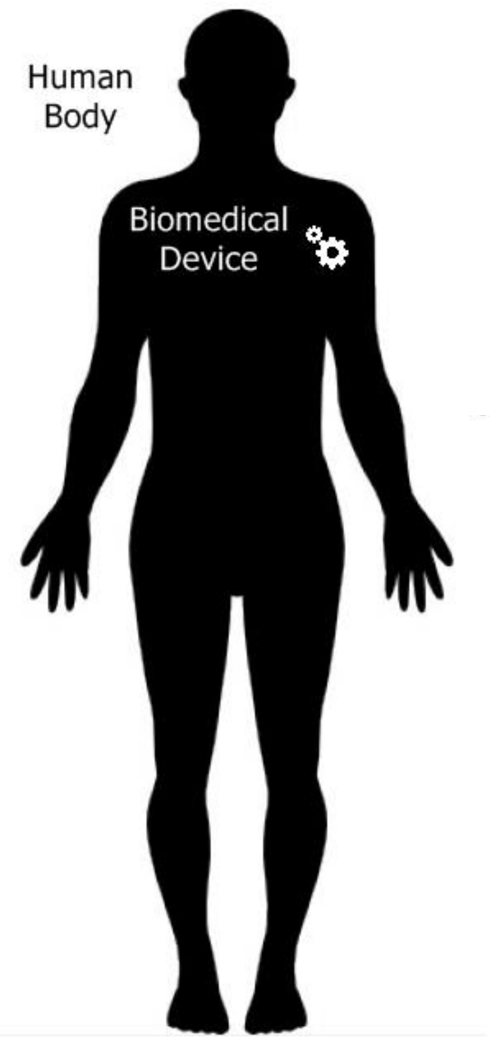
In the healthcare system, wireless on-body devices are being introduced, as they enable noninvasive monitoring of vital signs. However, certain challenges remain unresolved, among them miniaturization, security, standardization, energy efficiency, robustness and unobtrusiveness.



1. Introduction

Most **in-body devices** are still in development. These devices first appeared in 1958, when *Rune Elmgvist et al.* succeeded in implanting the first pacemaker in a human body. Since then, in-body devices, commonly known as **Implantable Medical Devices**, have covered a niche area when physiological parameters are only accessible from inside the human body or when wearable devices were not sufficiently powerful. Nevertheless, apart from implanted pacemakers and some ingestible endoscopic capsules with biotelemetry capabilities, not many in-body medical devices are available on the market; most of them are still in development, at testing or prototyping stage.

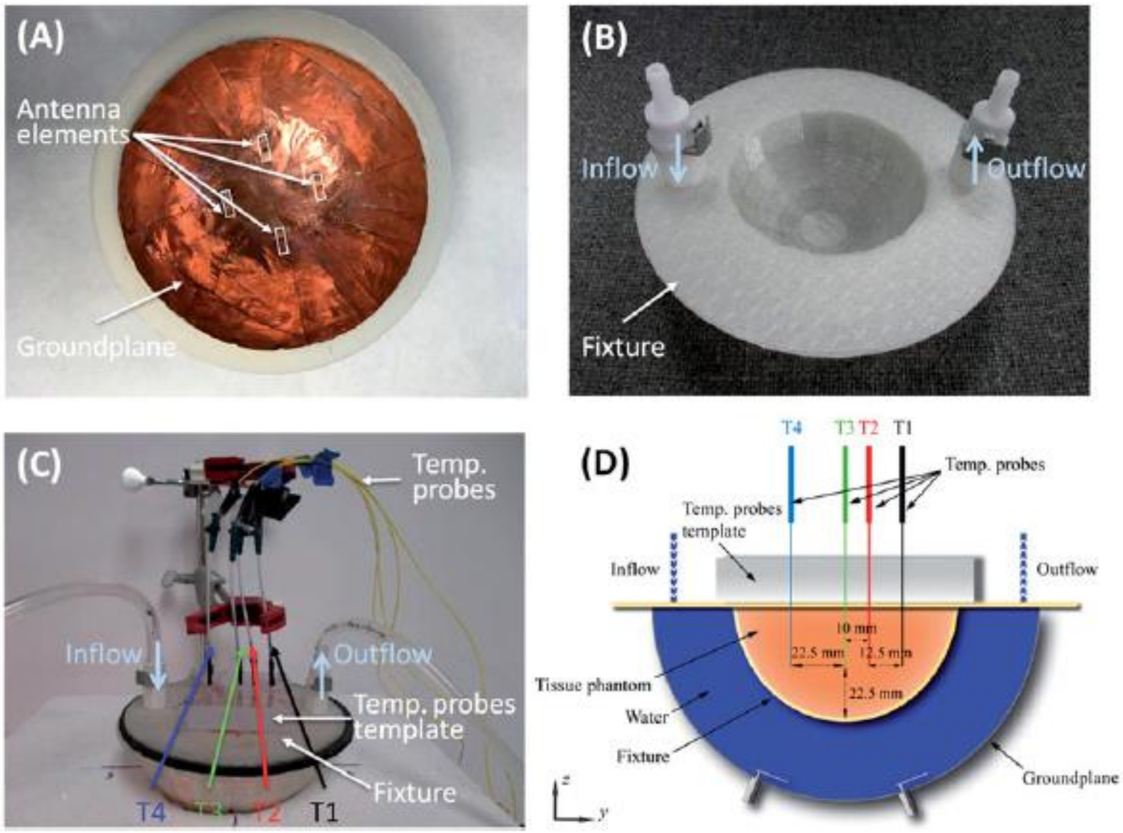
In-body wireless devices are classified in **implantable, ingestible or injectable** depending on their method of insertion into the human body. These devices open up a promising spectrum of new healthcare applications, but the list of challenges to overcome is still longer and more demanding than in the case of wearables: a greater level of miniaturization, biocompatibility, safety considerations, powering, and so on.



1. Introduction

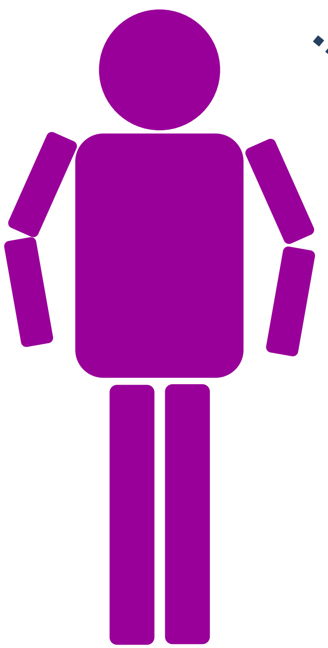
Not only monitoring → therapies

Example: microwave applicator for the treatment of breast cancer through hyperthermia.



Scenarios

Channel



Off-body

The channel is off of the body and in the surrounding space, only one antenna in the communications link is on the body. This is referred to as the off-body domain.

On-body

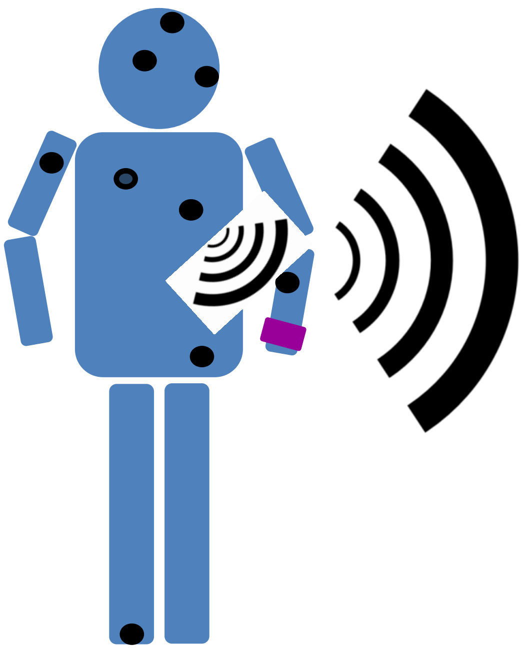
Most of the channel is on the surface of the body and both antennas will be on the body. This is called the on-body domain.

In-body

A significant part of the channel is inside the body and implanted transceivers are used. This is called the in-body domain.

1. Introduction

Scenarios



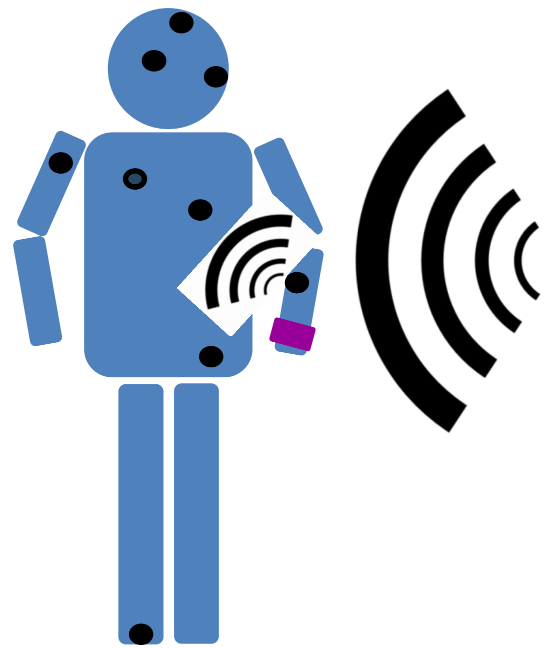
On ←→ Out

On ←→ On

In ←→ On

In ←→ Out

In ←→ In



2. Market Analysis

https://www.youtube.com/watch?v=cM4aep7VXb8

According to the **IDTech report** [1], the increasingly diverse market for wearable devices will reach over $150bn annually by 2027. This report contains 10-year forecasts (2017-2027) across 39 categories of wearable technology device, segmented by product type, industry and location on the body.

Industry	Product types	Body location

• Healthcare & medical
• Fitness & wellness
• Infotainment
• Commercial
• Industrial
• Military
• Other
• Multi-sector
	• Smartwatches
	  ○ Including case studies on product evolution relative to the future of smartphones and new standalone personal communication devices
	• Fitness trackers
	  ○ Including wrist-worn (in two separate categories), chest worn, the move to apparel and other form factors (clip-on, ear-worn, etc.)
	• Smart eyewear
	  ○ *Including virtual reality (VR), augmented (AR) and mixed reality, smart contact lenses*
	• Smart clothing:
	  ○ *Including elite sportswear, consumer sports apparel, heated apparel, chest straps, medical apparel, fashion apparel, workwear monitoring apparel, military apparel and others*
	• Medical devices:
	  ○ *Including breakdown by disease vertical, e.g. diabetes (sensors & pumps), cardiovascular treatments and monitoring, skin patches (physical, chemical, body area mapping), contact lenses (glaucoma, diabetes, etc.), hearing aids, neurological treatments, diagnostics devices, and others*
	• Other infotainment devices:
	  ○ *Including headphones (basic and smart, low and high end) and electronic watches*
		• Head
		• Ear
		• Eyes
		• Body (torso)
		• Arms
		• Wrist
		• Legs & feet
		• Implantable
		• Multi-location / adaptability by user or use case

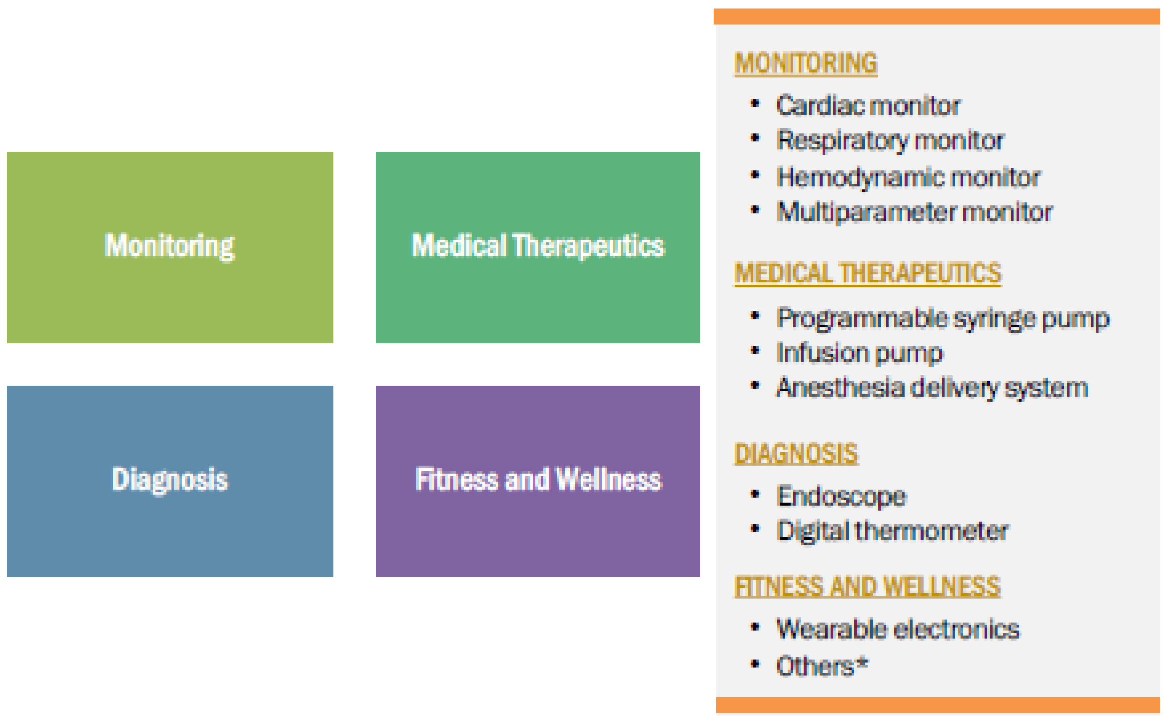
Wearable Technology 2017-2027: Markets, Players, Forecasts – IDTech 2017

IDTechEx

2. Market Analysis

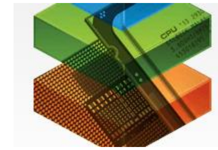
Wireless Portable Medical Device Market by **MarketsandMarkets** [2] Analysis by Technology (BT/BLE, Wi-Fi, ZigBee, ANT+), Component (Sensors, ICs, Processors), Application (Monitoring, Medical Therapeutics, Diagnosis, Fitness & Wellness), and Geography, Global Forecast to 2020

FIGURE 1 WPMD MARKET, BY APPLICATION



2. Market Analysis

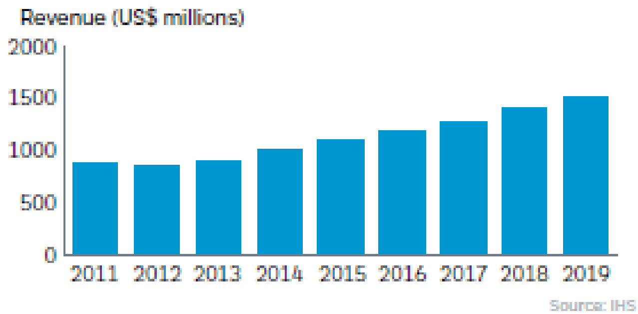
IHS Markit | TECHNOLOGY [3]



Wearable Market White Papers

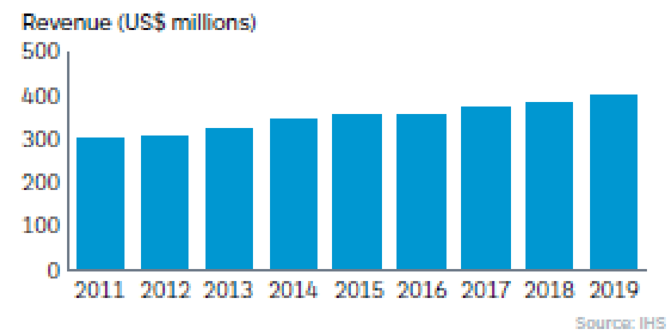
percent starting from 2011.

Global Revenue Forecast for Insulin Pumps



Examples of manufacturers in this market are Animas One Touch, Asante Snap, CeQur PaQ, Insulet Omnipod, Roche Diagnostics Accu-Chek, Smiths

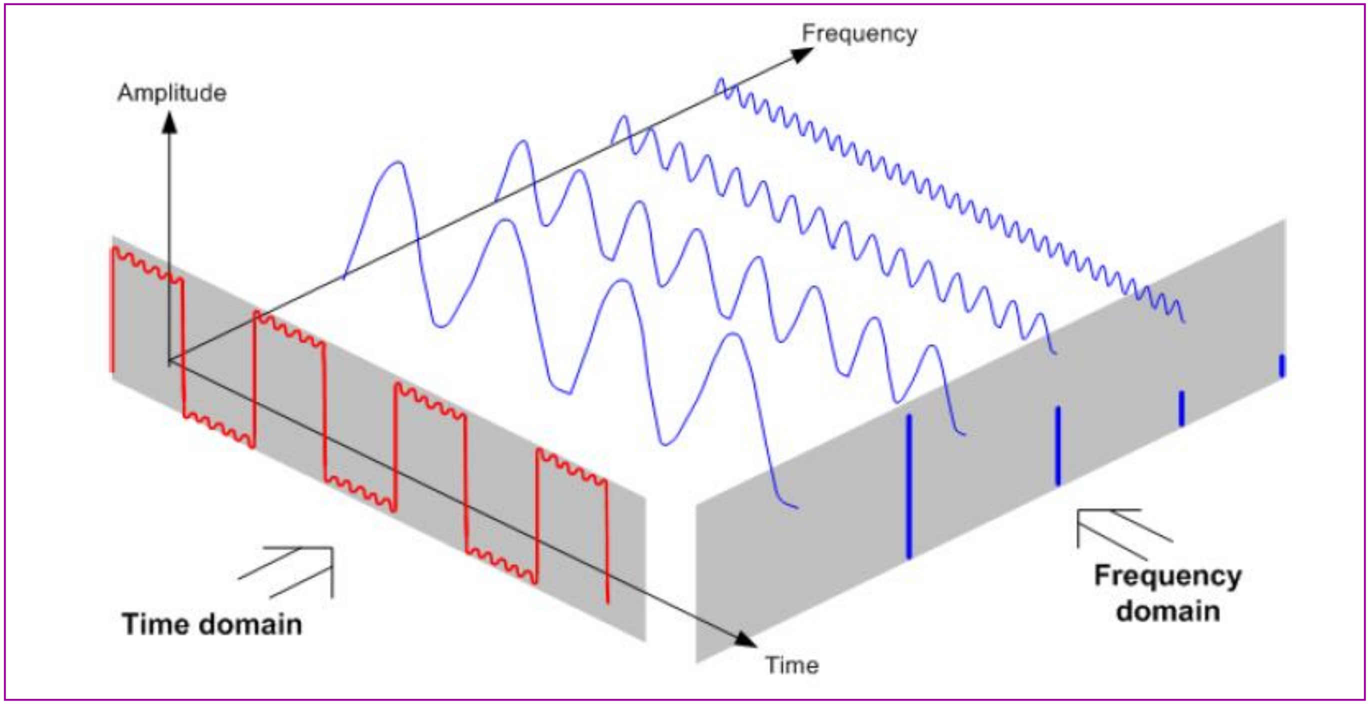
Global Revenue Forecast for Continuous Glucose Monitoring (CGM) Sensors



Basic questions

How can we establish communications?

Using waves and modifying some of their characteristics: amplitude, phase, frequency.



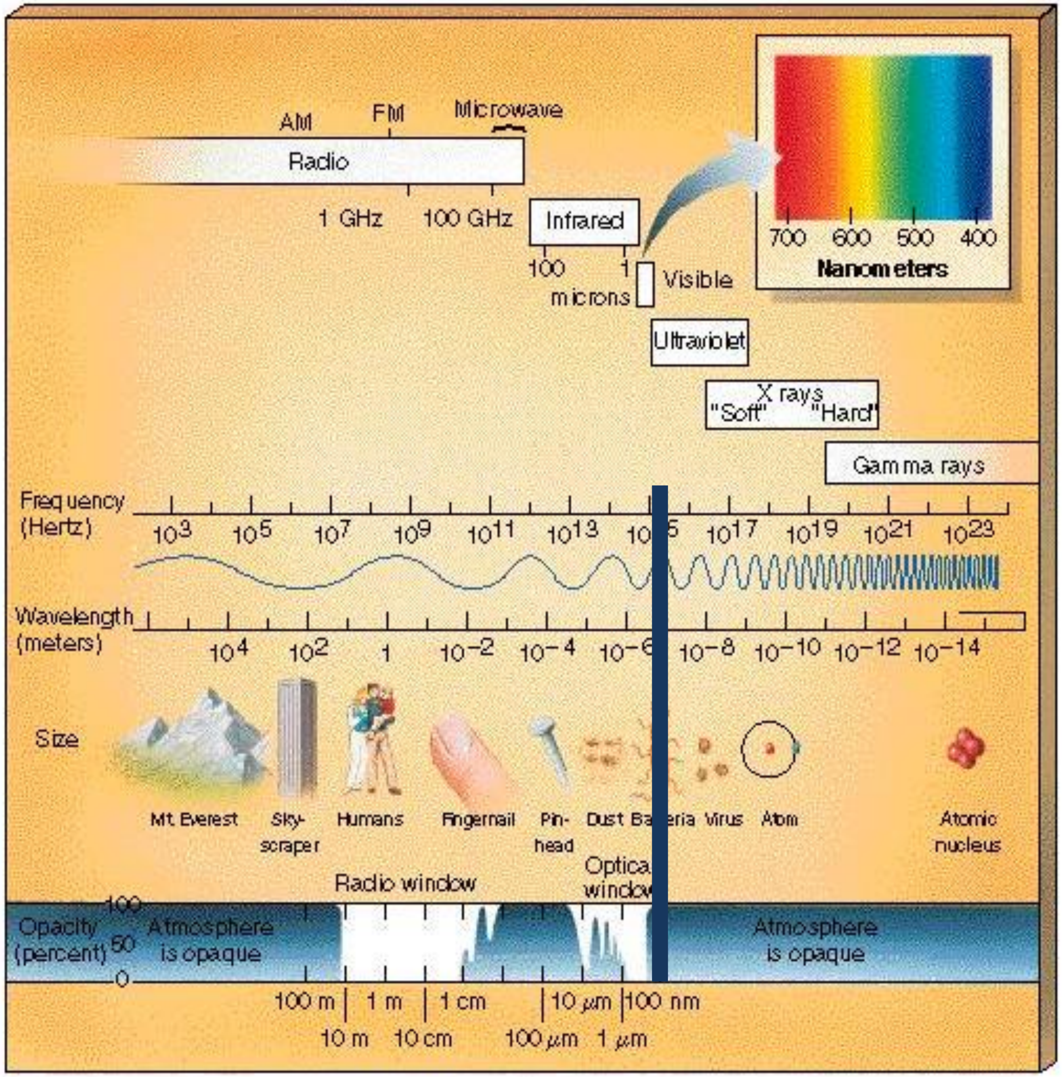
R&S®FSH4/8
Spectrum Analyzer
Operating Manual

Internet: http://www.rohde-schwarz.com

What parameters characterize the propagation of signals?

permitivity (e), conductivity (s), permeability (m)

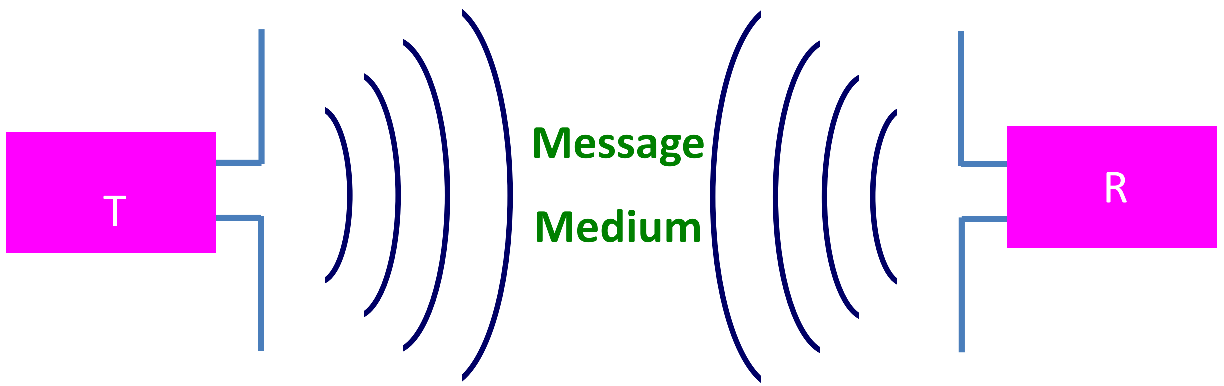
What kind of radiation do we use to stablish wireless communications? Why?

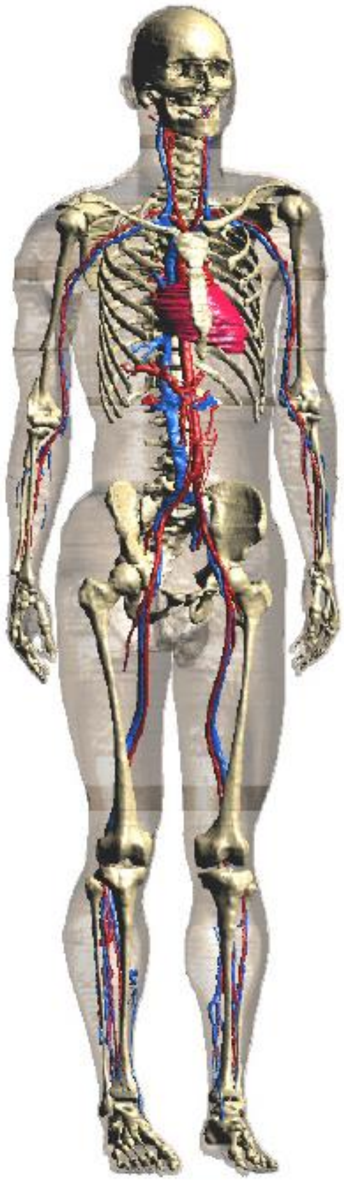


http://www.astro.princeton.edu/~gk/A402/pix.html

What do we calculate/measure to characterize propagation of signals?
Electromagnetic fields

How can we generate electromagnetic waves for wireless communications?
Using antennas.
An antenna is a device used to transform a RF signal, traveling on a conductor, into an electromagnetic wave.
Antennas have *reciprocity*, an antenna will maintain the same characteristics regardless if it is transmitting or receiving.





What is SAR?

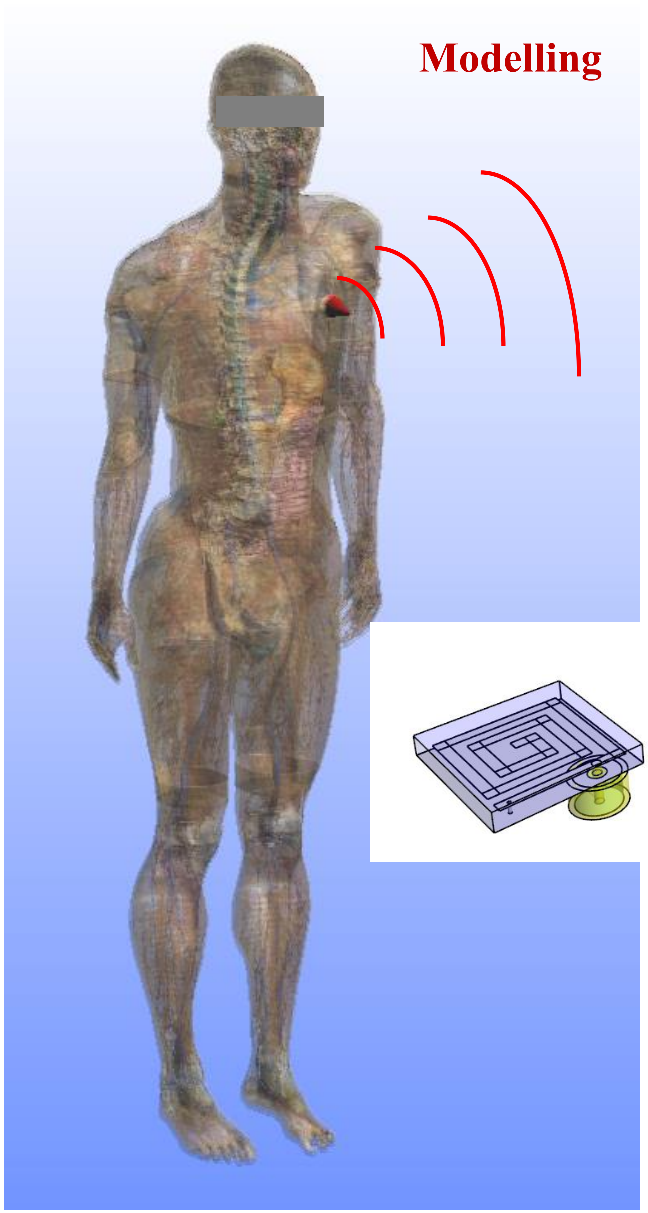
The specific absorption rate (SAR) is defined as transferred power divided by the mass of the object. Specific refers to the normalization to mass, and absorption rate to the rate of energy absorbed by the object. For sinusoidal steady-state EM fields the time-average SAR is given by:

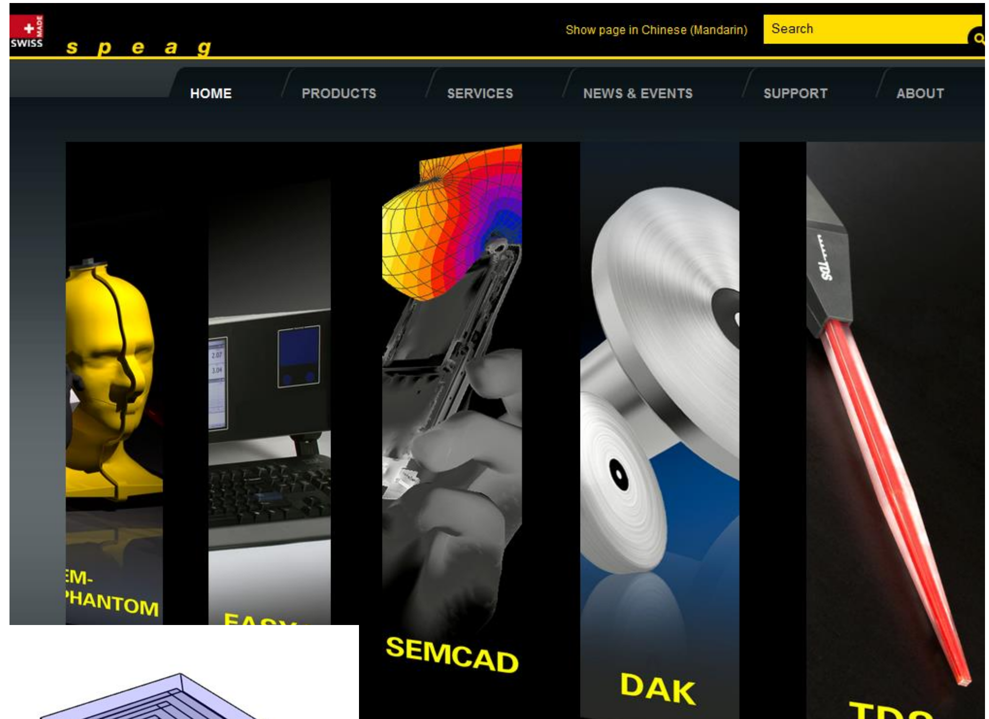
$$\boxed{SAR = \sigma_{eff}\, E_{rms}^{2}/\rho \quad (W/kg)}$$

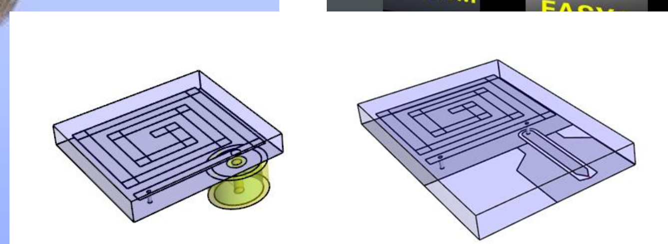
where ρ is the mass density of the object in kg/m^3, which is close to 1.0 kg/m^3 for most biological tissues (except for lung, which is about 0.347 kg/m^3).

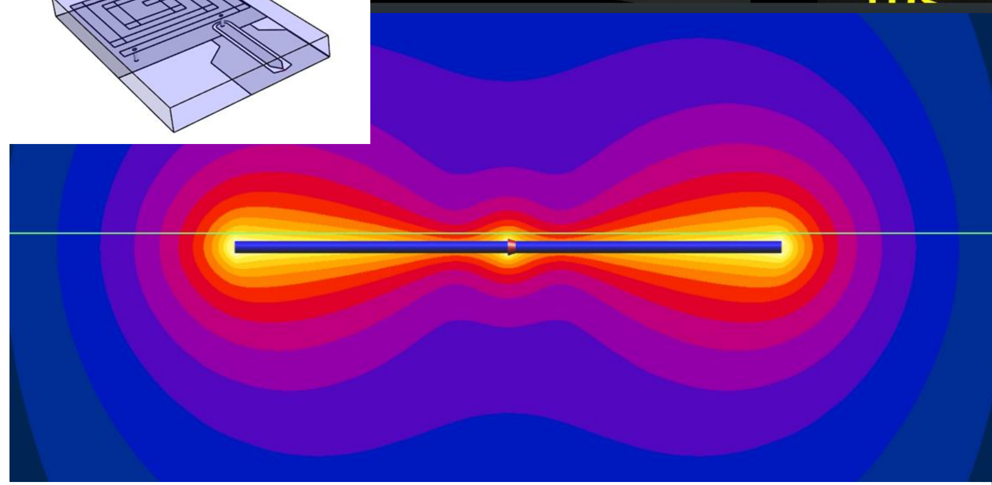
This is a point relation, so it is often called the local SAR. The space-average SAR for a body or a part of the body is obtained by calculating the local SAR at each point in the body and averaging over the whole body or the part of the body being considered.

3. Fundamentals

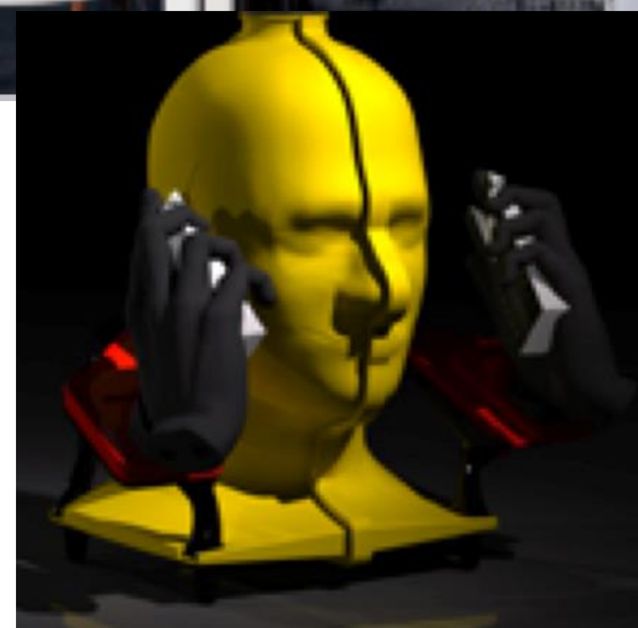






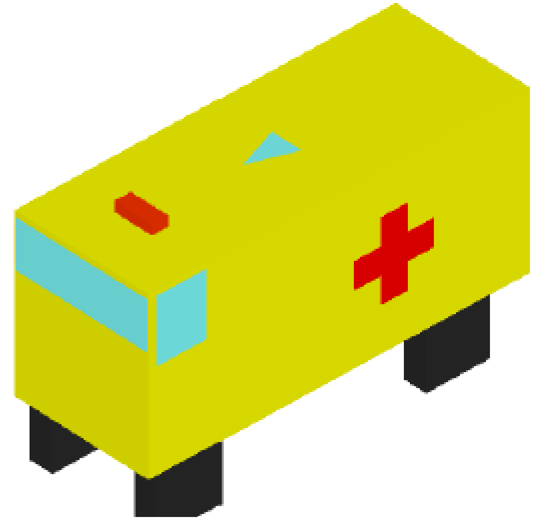


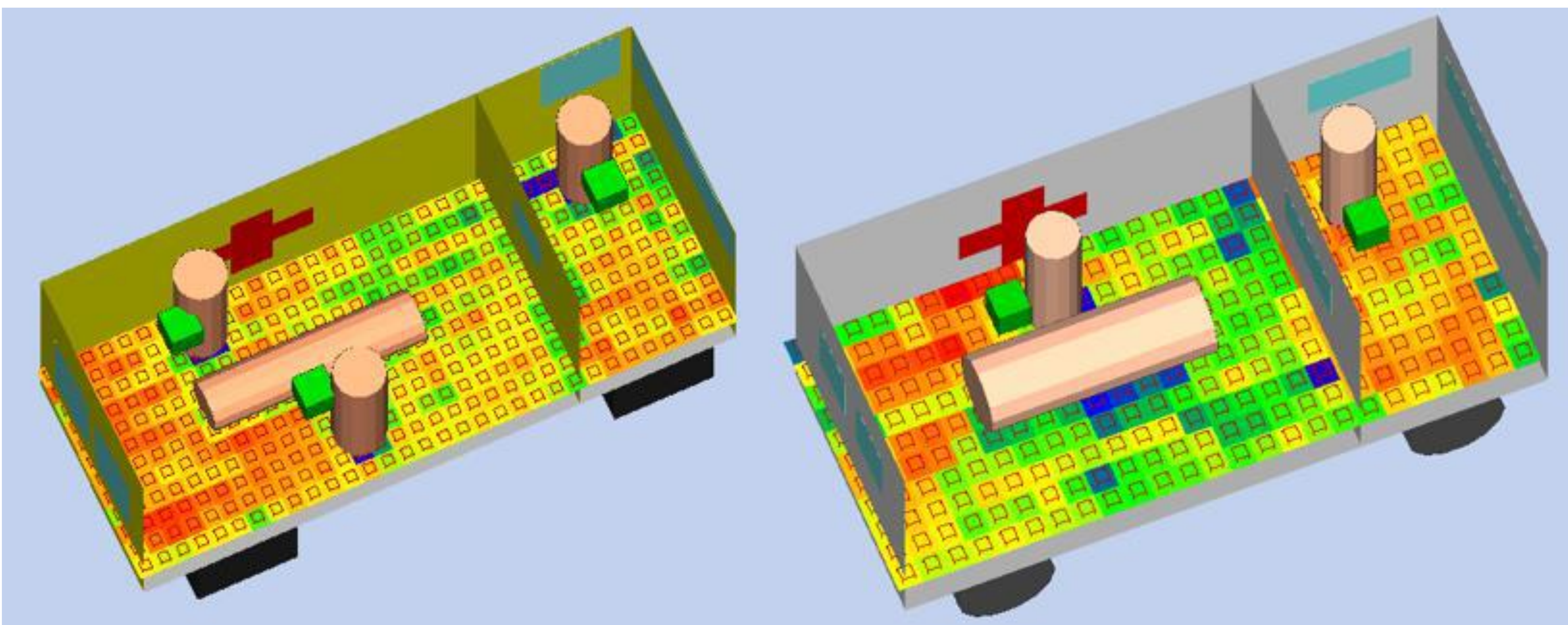
What is a phantom?



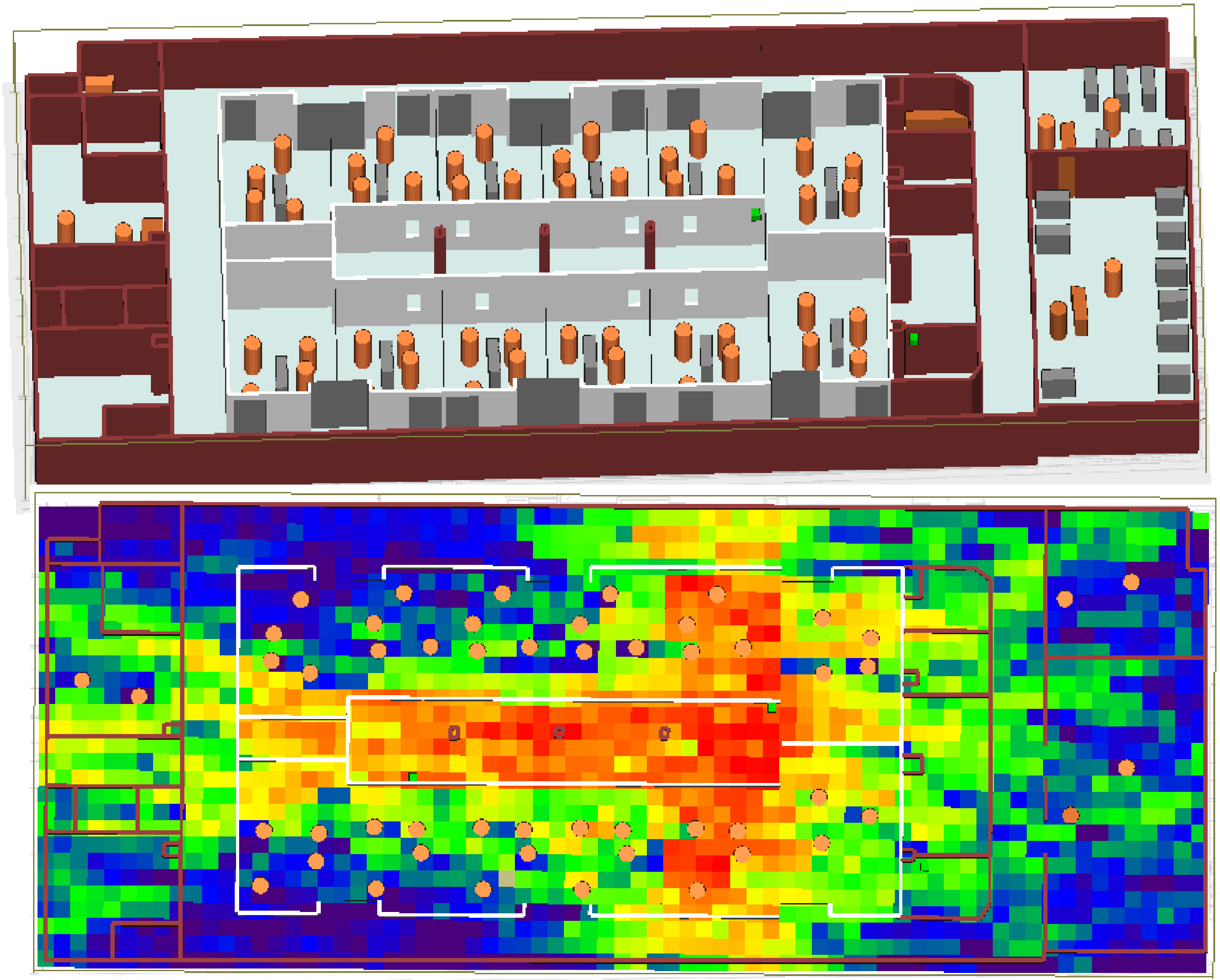
Schmid & Partner Engineering AG

3. Fundamentals





3. Fundamentals



4. LAB

1. Examples: far field, near-field devices, antennas
2. Spectrum analyzer: levels, bands, technologies
3. Anechoic chamber
4. Spectrum analyzer inside the chamber
5. Phantoms
6. Measurements