DEVELOPING HEARING AIDS THROUGH ELECTROMAGNETIC SIMULATION TECHNOLOGY

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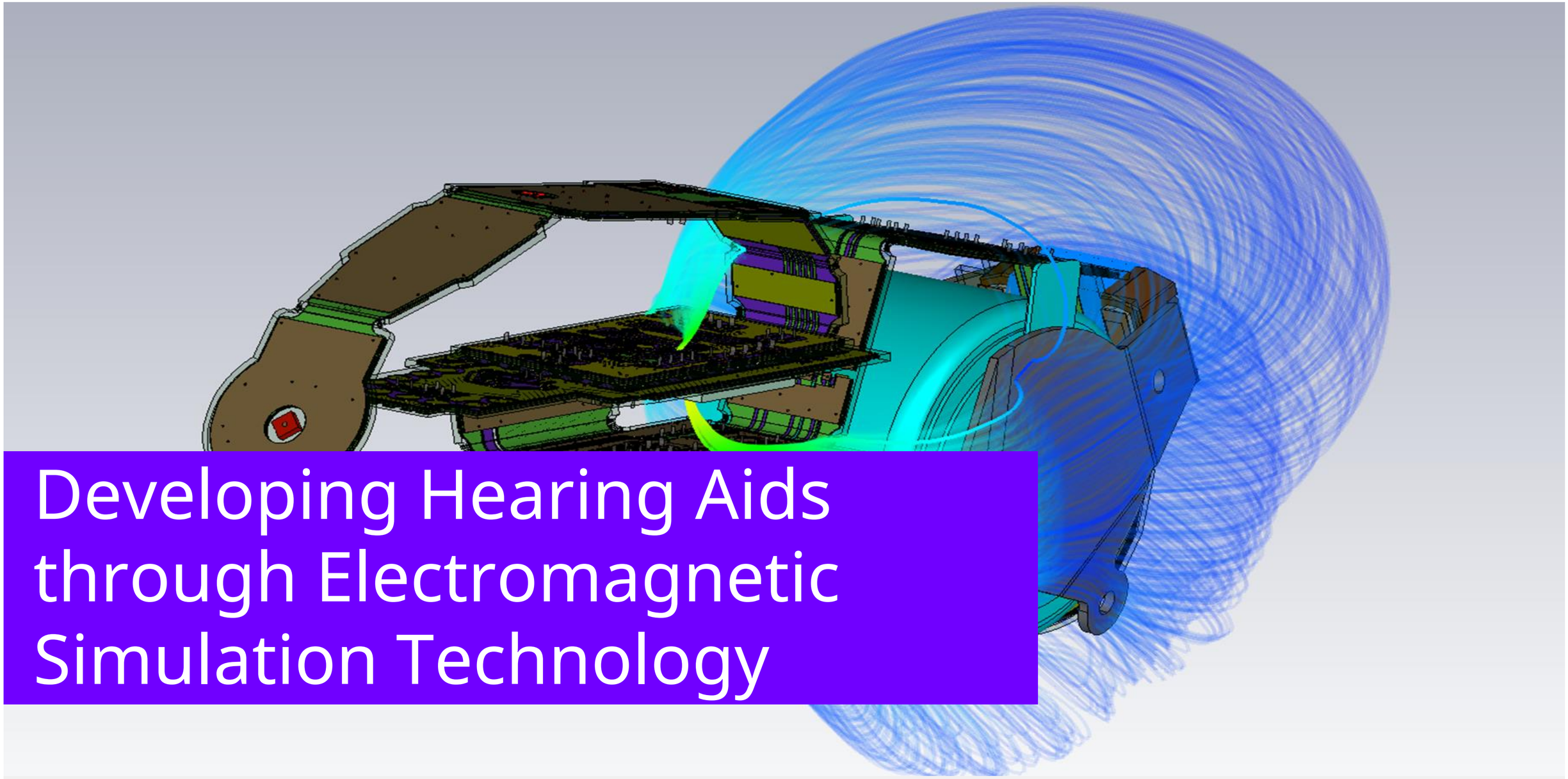

Developing Hearing Aids through Electromagnetic Simulation Technology

3DEXPERIENCE Conference EuroCentral 2024, Oct, 16th to 17th, Munich

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According to WHO
there are

1.6

billion people with
hearing loss worldwide;
430m people with
disabling hearing loss*

... of whom

15-20%

currently use hearing aid devices

*A hearing loss of more than 35 dB in the better-hearing ear.

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Who is WS Audiology (WSA)?

A global hearing aid pure player with strong brands

History

2019

Sivantos + Widex merger

140+

years of combined experience

€2,465m

of revenue FY 2022/23

R&D powerhouse

€170m

annual R&D spend

1,150+

people working in R&D

4

major R&D hubs

Global footprint

~12k

employees

+130

markets

45

offices

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Innovation highlights of the fiscal year 2022/23

EXPLORE OUR BRANDS

SIGNIA - BE BRILLIANT

Pure Charge&Go IX and T IX

SIGNIA – BE BRILLIANT

Silk Charge&Go IX

WIDEX – SOUND LIKE NO OTHER

Moment Sheer™ sRIC R D

WIDEX – SOUND LIKE NO OTHER

Sound Assist™

REXTON - STUFF HAPPENS RUGGED CAN HANDLE IT

Rugged

VIBE – NEVER MISS THE PUNCHLINE AGAIN

WeChat Mini Program

HEAR.COM – HEARING AIDS WILL CHANGE YOUR LIFE

HORIZON AX

SONY – HEAR WHAT MATTERS MOST

CRE-E10

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Let’s get started

Hearing Aids are much more than you can imagine

Introduction (I)
Modern Hearing Aids are much more than audio amplifiers

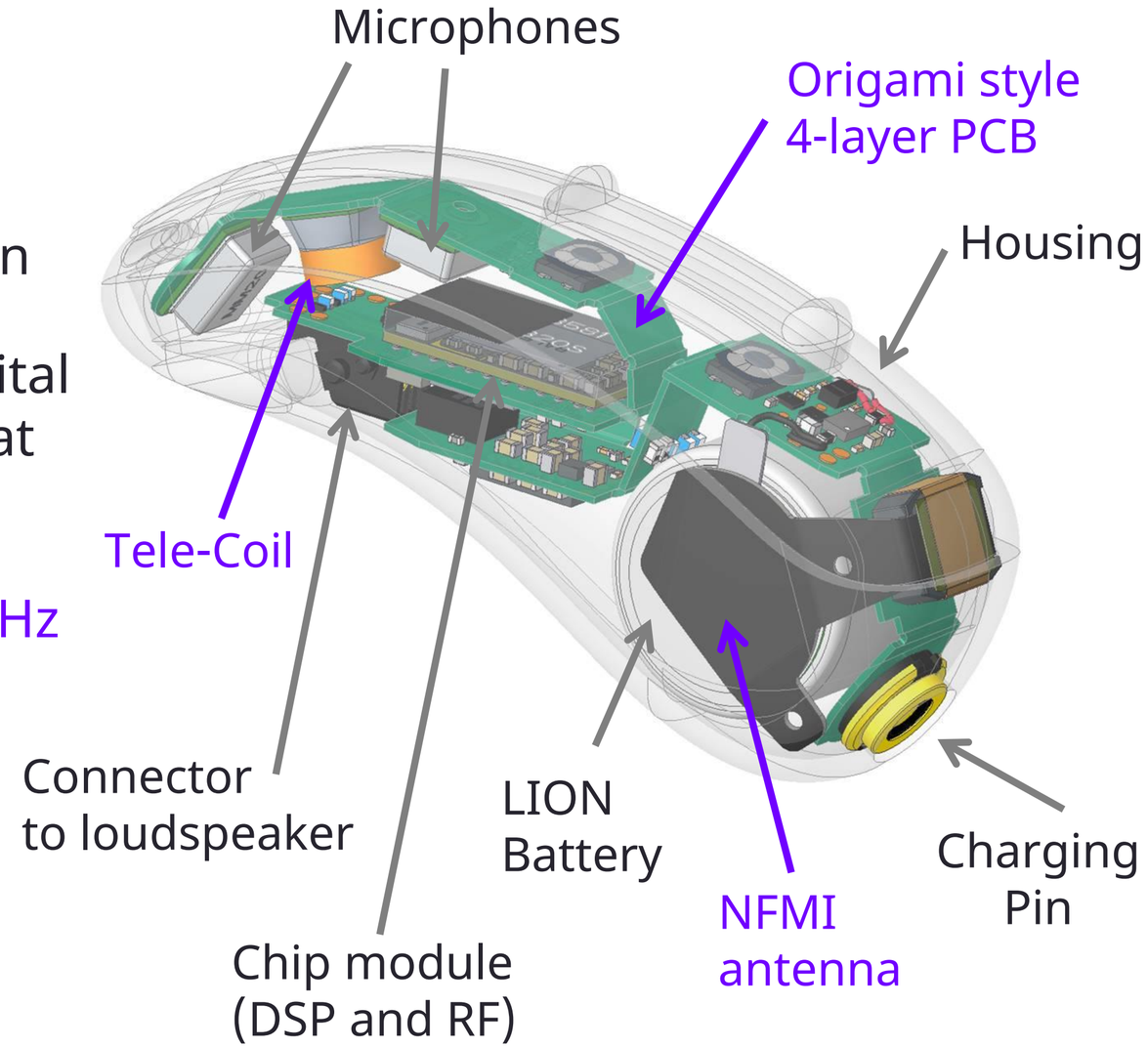
- Three different wireless systems

  Magnetic Tele-Coil working at acoustic frequency range for magnetic signal reception

  Ear to ear (e2e) communication based on digital near field magnetic inductive (NFMI) system at 3 MHz with special flange antenna

  Digital Radio Frequency (RF) system at 2.45 GHz with PCB mainboard as antenna

- Lots of other electronics inside hearing aid interfering these wireless systems



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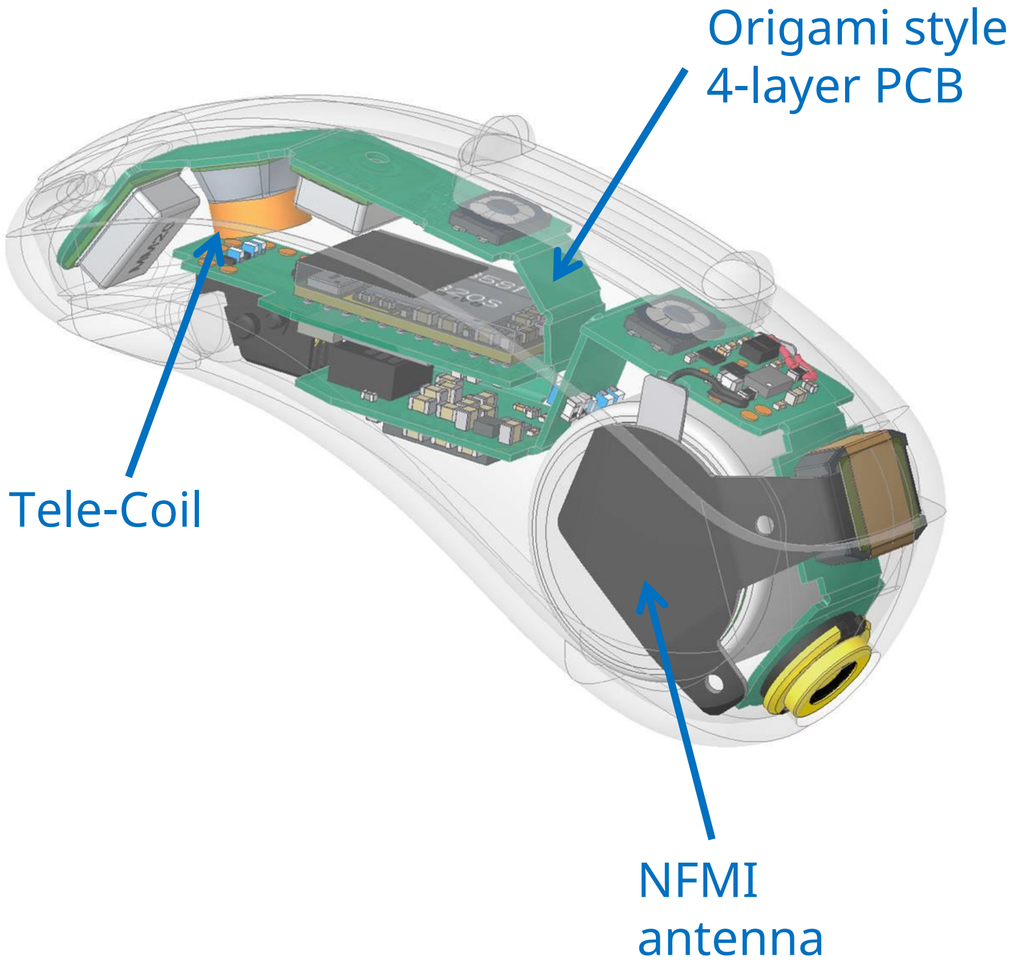
Introduction (II)
Questions during development of wireless systems

- What is the performance of the antennas?



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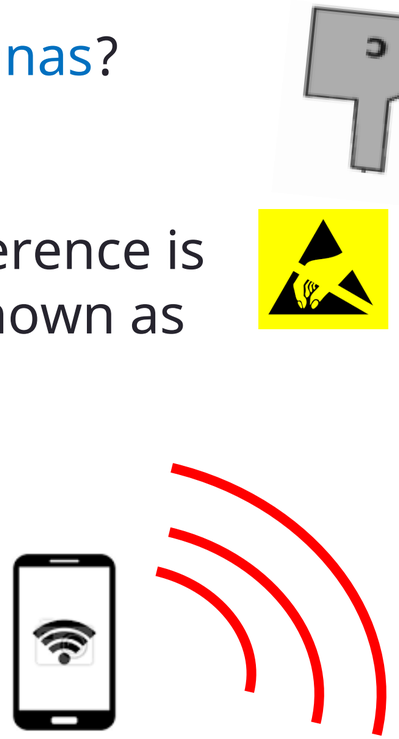
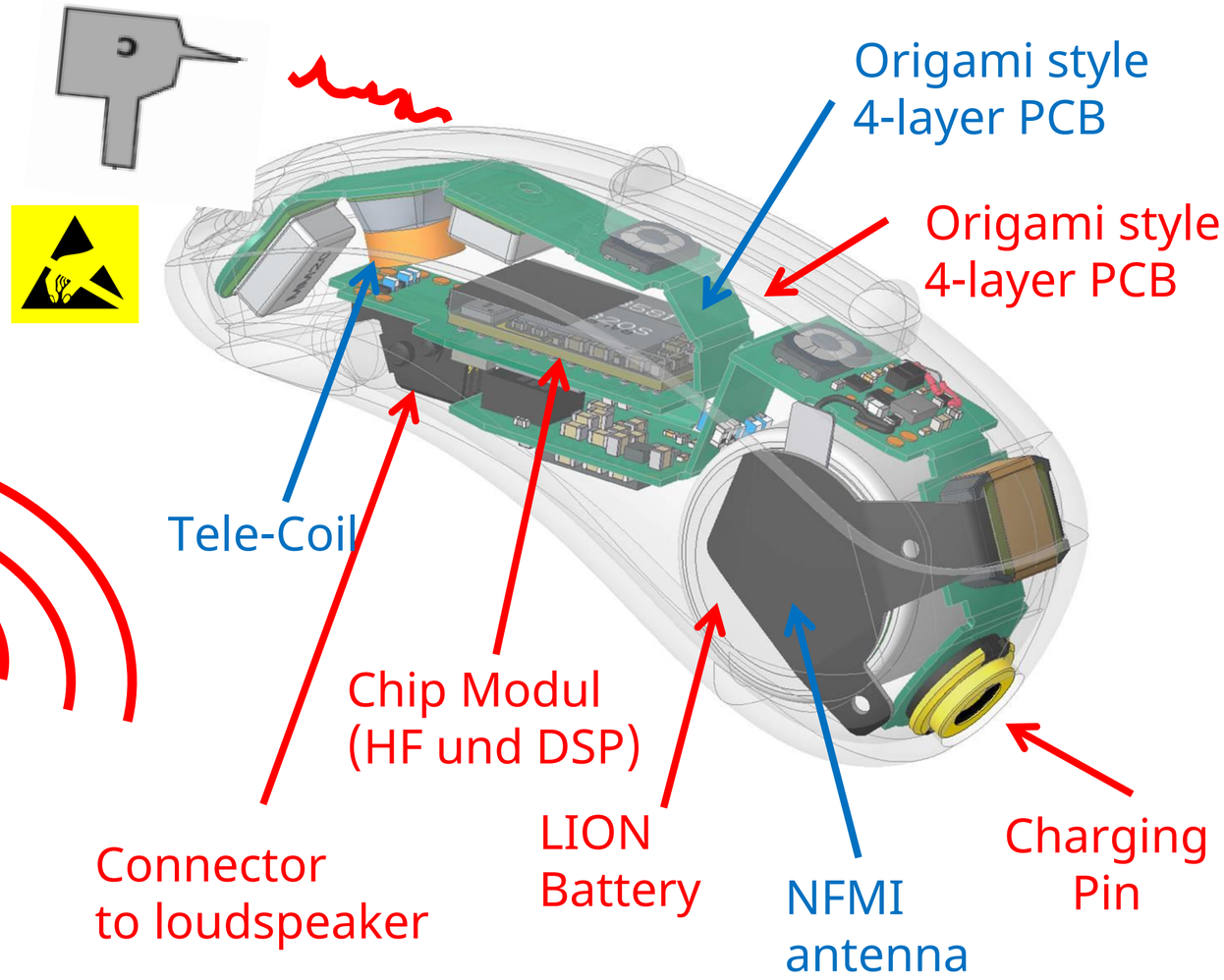
Introduction (III)
Questions during development of wireless systems

- What is the performance of the antennas?

- How much internal or external interference is coupling into the antennas? This is known as Electromagentic Compatibility (EMC)
  - Antennas as Victim
  - Internal Agressor
  - External Agressor
    - Electrostatic Discharge
    - RF interference from Smartphone





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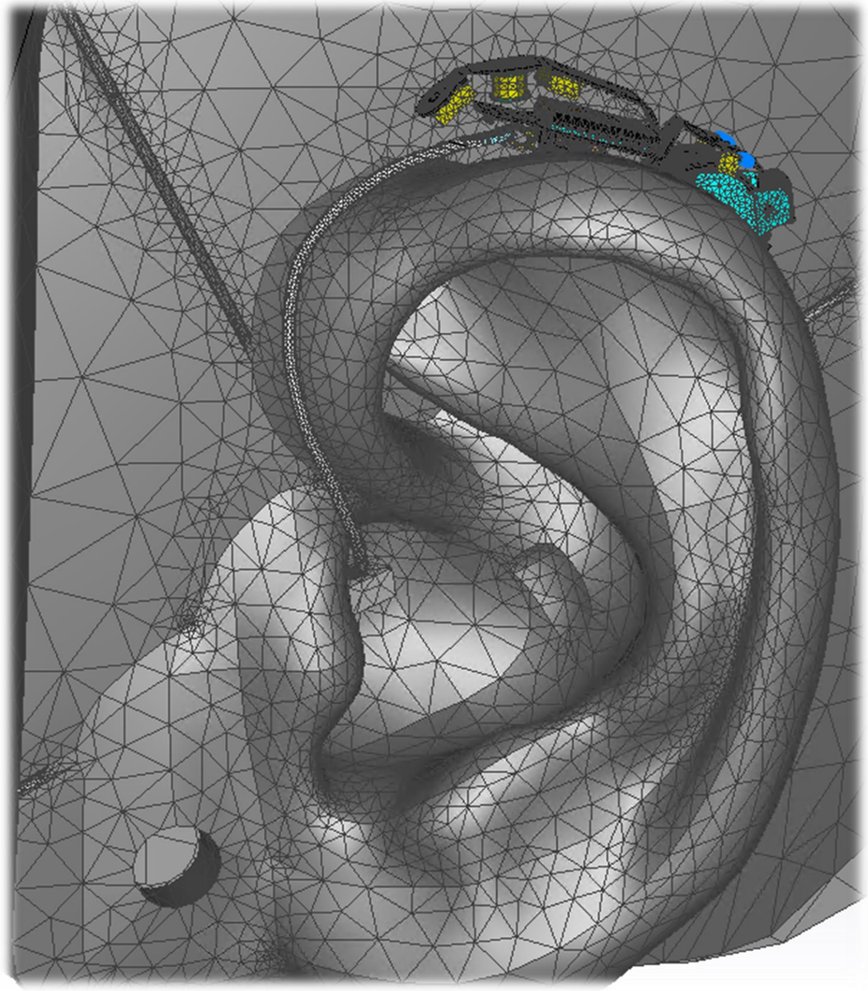
Motivation
Simulation with Dassault CST Studio helps to

→ Deliver good performance on the very first Hardware (HW) iteration already

→ Understand electromagnetic effects that are hard to measure or to proof outside simulation

→ Develop sophisticated and very small antennas and hearing aids

→ Reduce HW iterations or development time



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Technology: How is the modeling done?

Complex geometry and complexity over the frequency range

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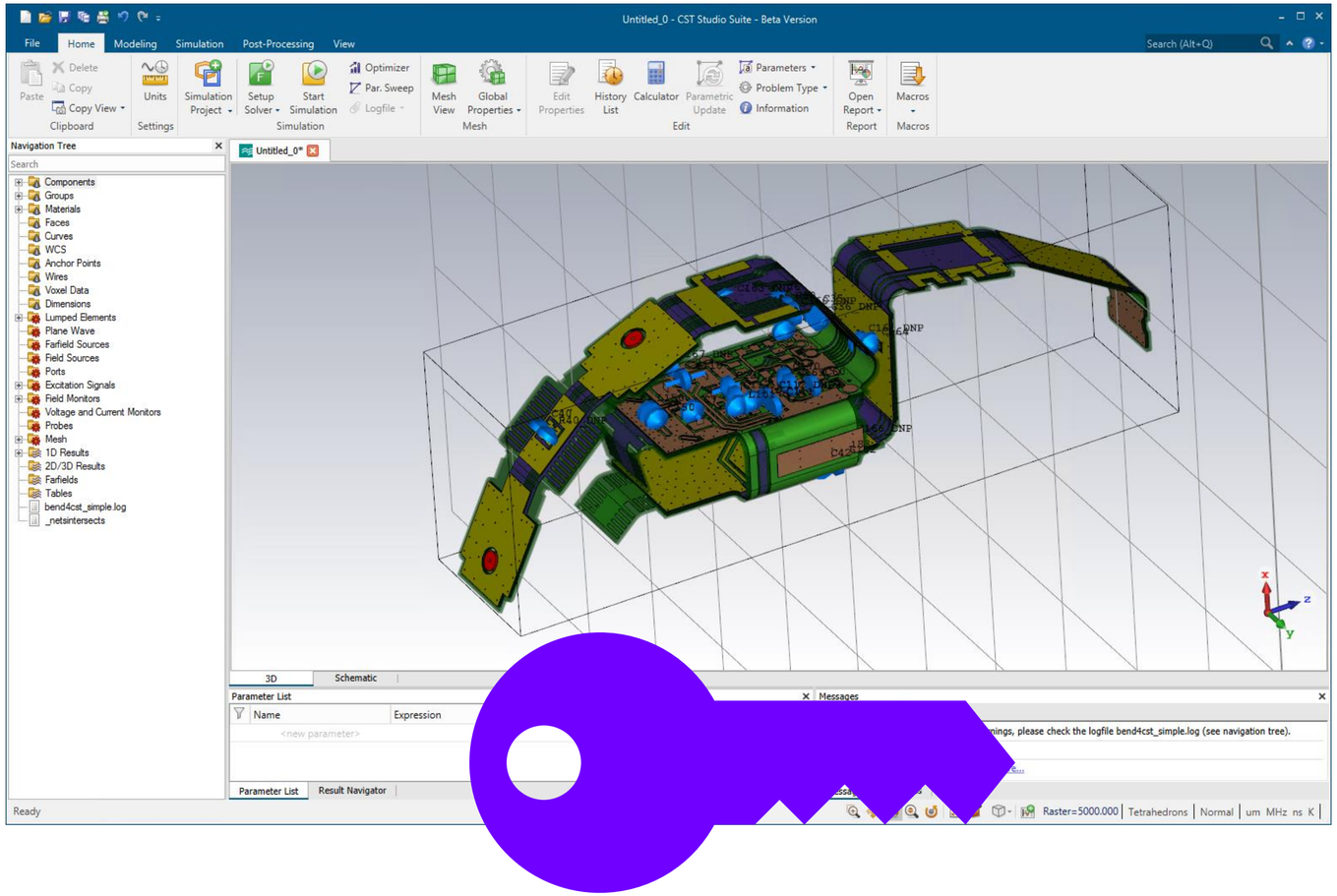
How is the modeling done – the circuit board?

- Multi-bent circuit board with many components
- Simple circuit board import with automatic bending only since Dassault CST Studio 2020 within minutes
- Import of electrical information (net names, structure, components as lumped elements)
- Key to the spread/acceptance of simulation



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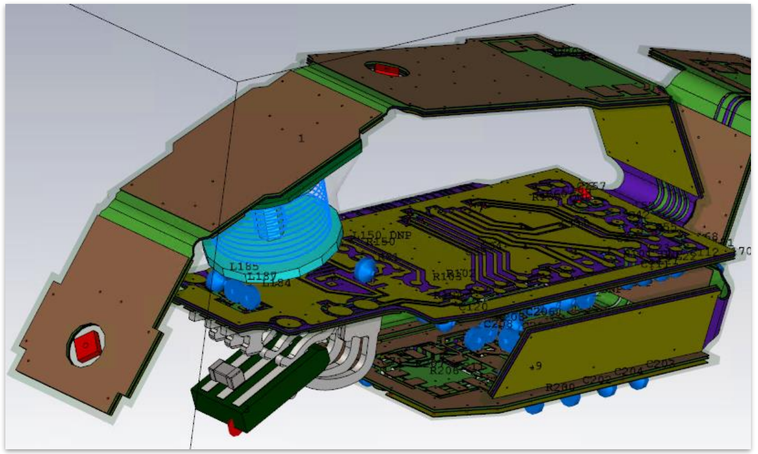
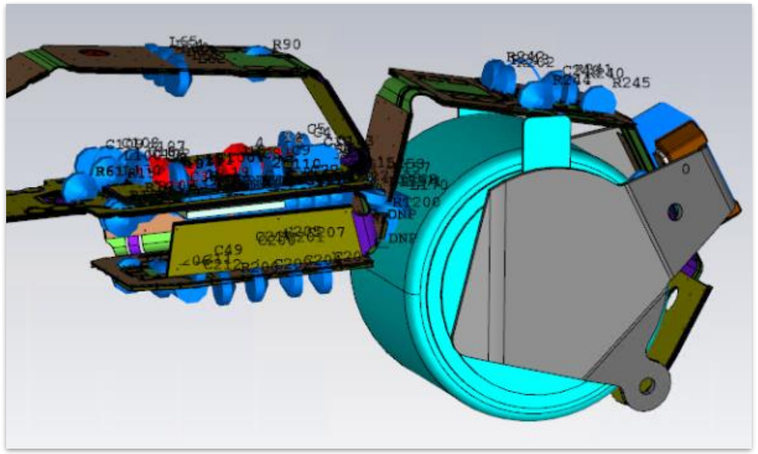
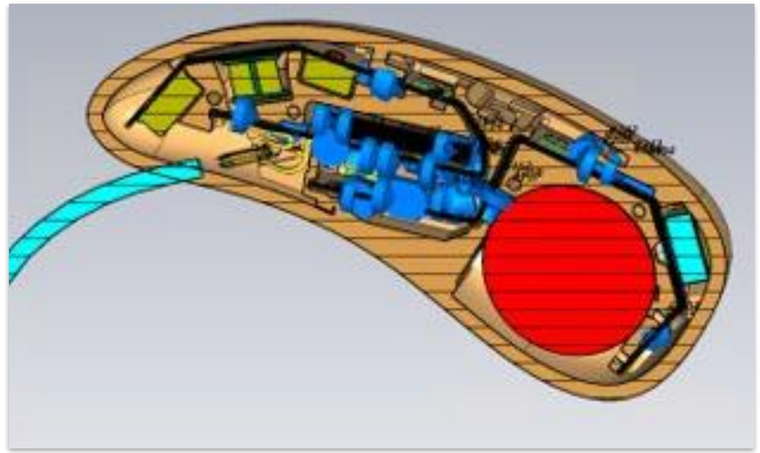
How is the modeling done – over the frequency?







Complexity

T-coil simulations (~kHz)

- MI antennas, MI interference coupling
- Magnetic coupling
- No frame/housing
- Simulation in the frequency domain
- TET-Mesh (tetrahedron)

NFMI simulations (~MHz)

RF simulations (~GHz)

- RF antennas
  RF interference coupling
- Complete model with ear
- Simulation in the frequency or time domain
- TET-Mesh or HEX-Mesh

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Technology: How can we simulate antennas?

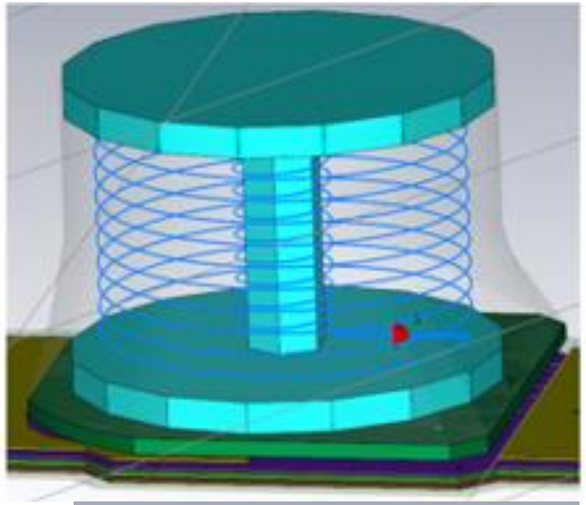
Simulation models and simulation steps

How can we simulate magnetic antennas?

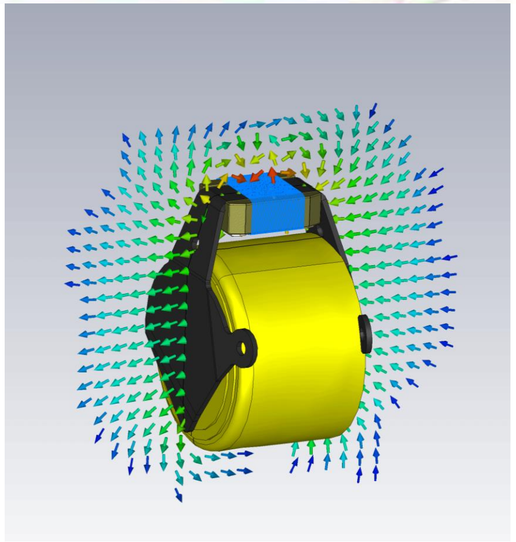
Structure of a magnetic antenna

- Ferromagnetic core
- N windings
- Ferromagnetic shields/foils

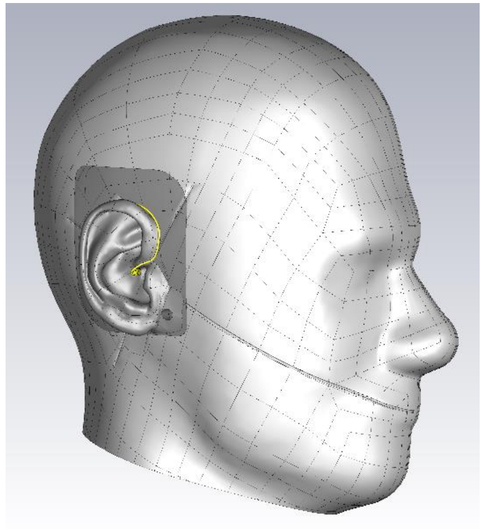
T-coil (5 kHz)
- Windings as thin wire model
- Simplified winding layers due to $N > 10000$



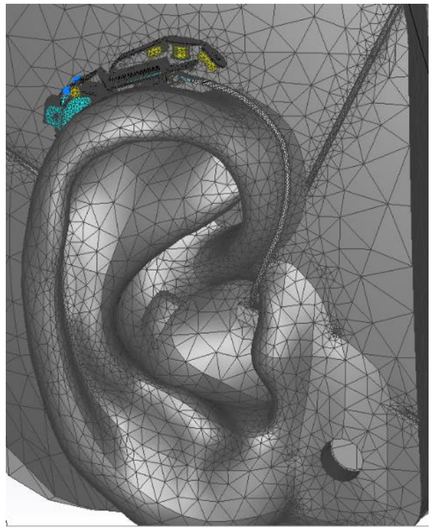
NFMI antenna (3 or 10 MHz)
- Windings as thin wire model
- Simulation of soft magnetic foils



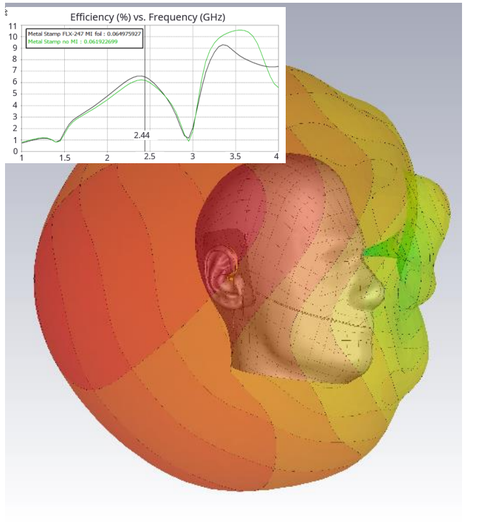
How can we simulate high-frequency antennas?



Hearing aid model with phantom head



Decomposition into tetrahedrons, simulation in the frequency domain



Far-field & antenna efficiency

Complete hearing aid and head create the antenna system
→ Antenna development is not possible without simulation

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Technology: How can we simulate interference coupling?

Electromagnetic compatibility in internal and external interference coupling

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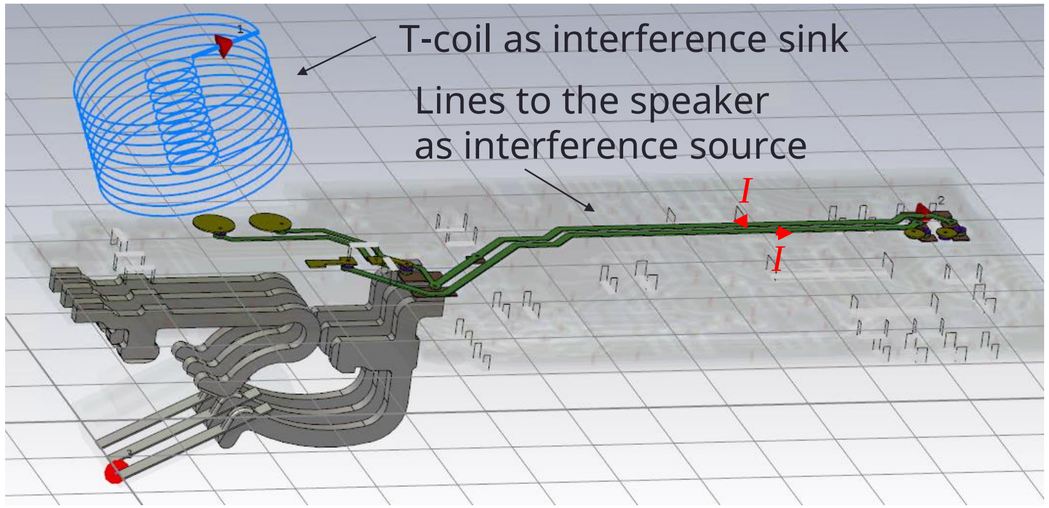
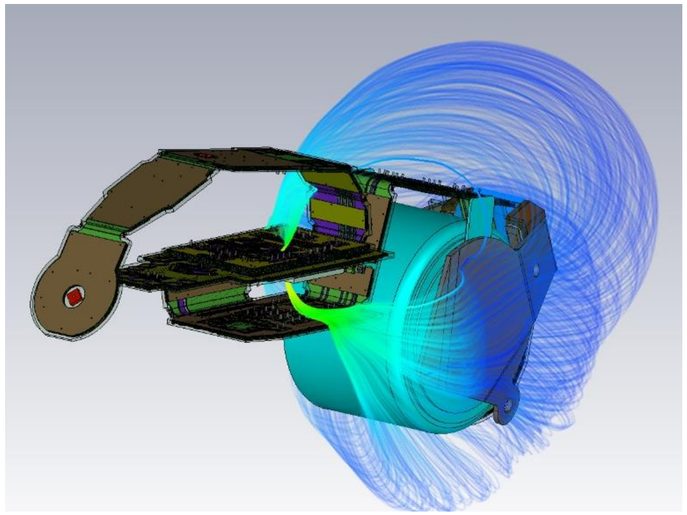
How can we simulate interference coupling? (I)

- Expert knowledge required for simulating interference

→ Example: Magnetic coupling through the field from current to and from the speaker



→ Example: Magnetic coupling of clocked voltage converters into the NFMI antenna



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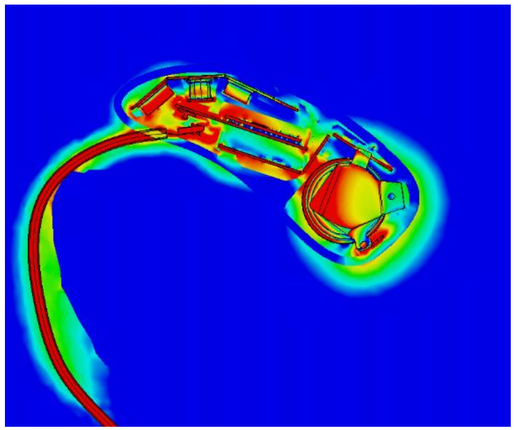
How can we simulate interference coupling? (II)

- What do we do if we do not yet know the interferers in a new chip/platform?

  → Reciprocal analysis exchanges the roles of victim and aggressor

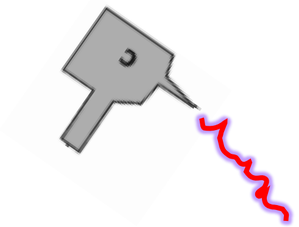


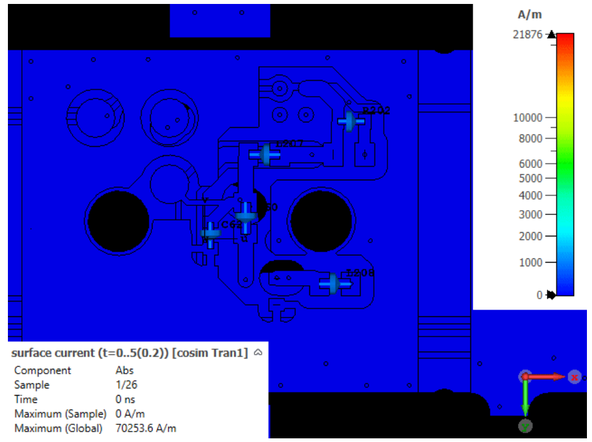
Red – High E-field through antenna

Green/Blue – Low E-field through antenna -> suitable for placement of interferers

- Simulation of external interference coupling due to nonlinearity requires deep knowledge -> Expert simulation

  → E.g.: Coupling of electrostatic discharge (ESD) onto the circuit board of the hearing aid





A. Mantzke, M. Leone, T. Fischer: Efficient analysis and reduction of magnetic near-field-coupling in mixed-signal PCBs via the reciprocity principle. 2015 IEEE International Symposium on Electromagnetic Compatibility (EMC)

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Organization: How do we structure simulation?

People, Processes

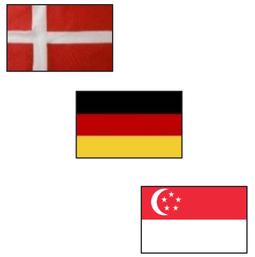
How is the simulation organized - Community? (I)

- EM Simulation Community with different specializations
- 20+ experts and users in Denmark, Germany and Singapore
- Regular exchange online and in person
- New simulation methods as a separate project with final verification
- Global simulation library with verified components
- Local server landscape for simulation and modeling with local remote access

How is the simulation organized- Roles? (II)

Simulation Key Expert

- One <Key Expert> per location
- Reference simulations, library
- Variety of simulation activities
- Building internal/external networks



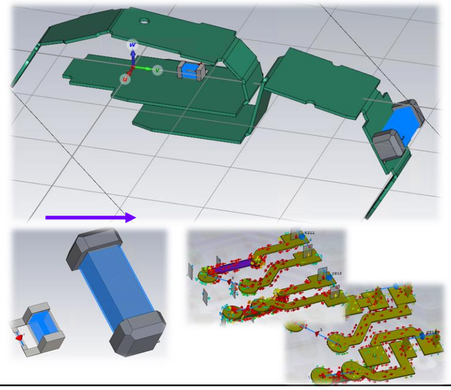
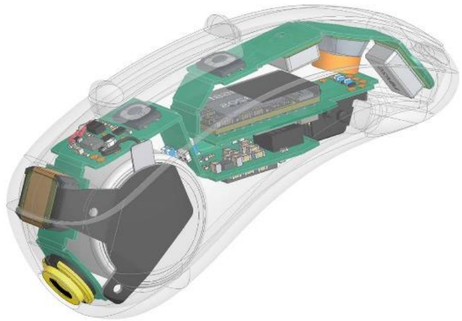
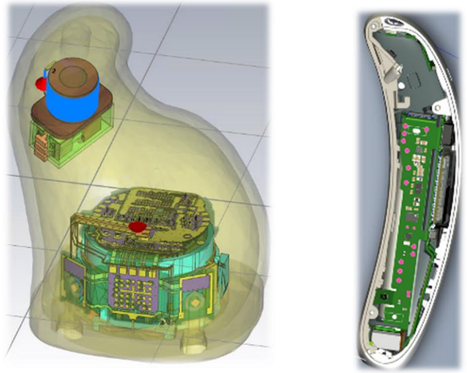
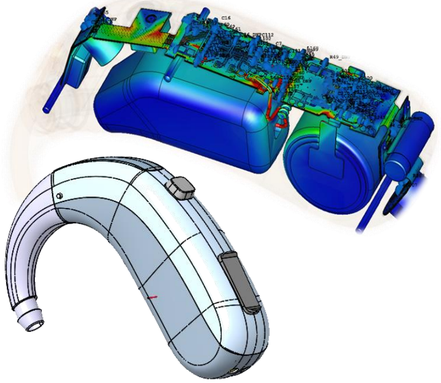
Simulation Expert

- Expert and experienced in field simulation
- Deep understanding of
  - Antennas and electronics
  - Measurement technology and EMC

Simulation User

- Basic training in field simulation
- Basic knowledge of field simulation
- Expert in another area
- Simulation is not a daily task

How is the simulation organized– Phases ? (III)

Description	Architecture Phase	First hearing aid new platform	Special form factors	Derived devices
				
When	As needed	Always	Purposeful	As needed
Role	Expert	(Key) Expert	User / Expert	User / Expert
Activities	- Feasibility - Placability	- Model generation for library - Understanding problems and performance	- Predicting problems and performance	- Understanding problems

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Summary

Summary

- Hearing aids are more than just amplifiers in a brown color
- Given the available space, antenna development and low interference coupling are only possible through simulation
- Virtual bending of circuit boards, electrical and magnetic material properties, and the correct mesh are essential for simulations
- Global organization of the simulation group with three user roles and task-dependent

Thank you for your attention …

Questions?

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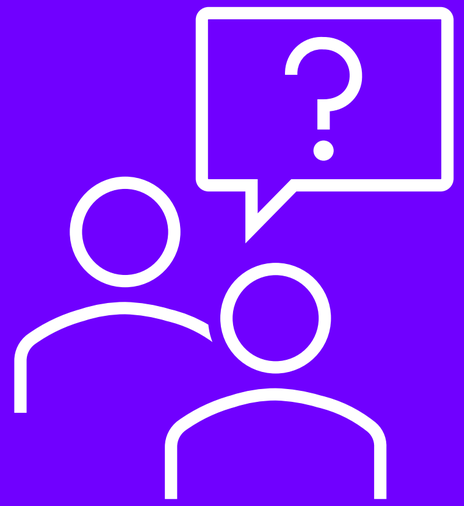

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