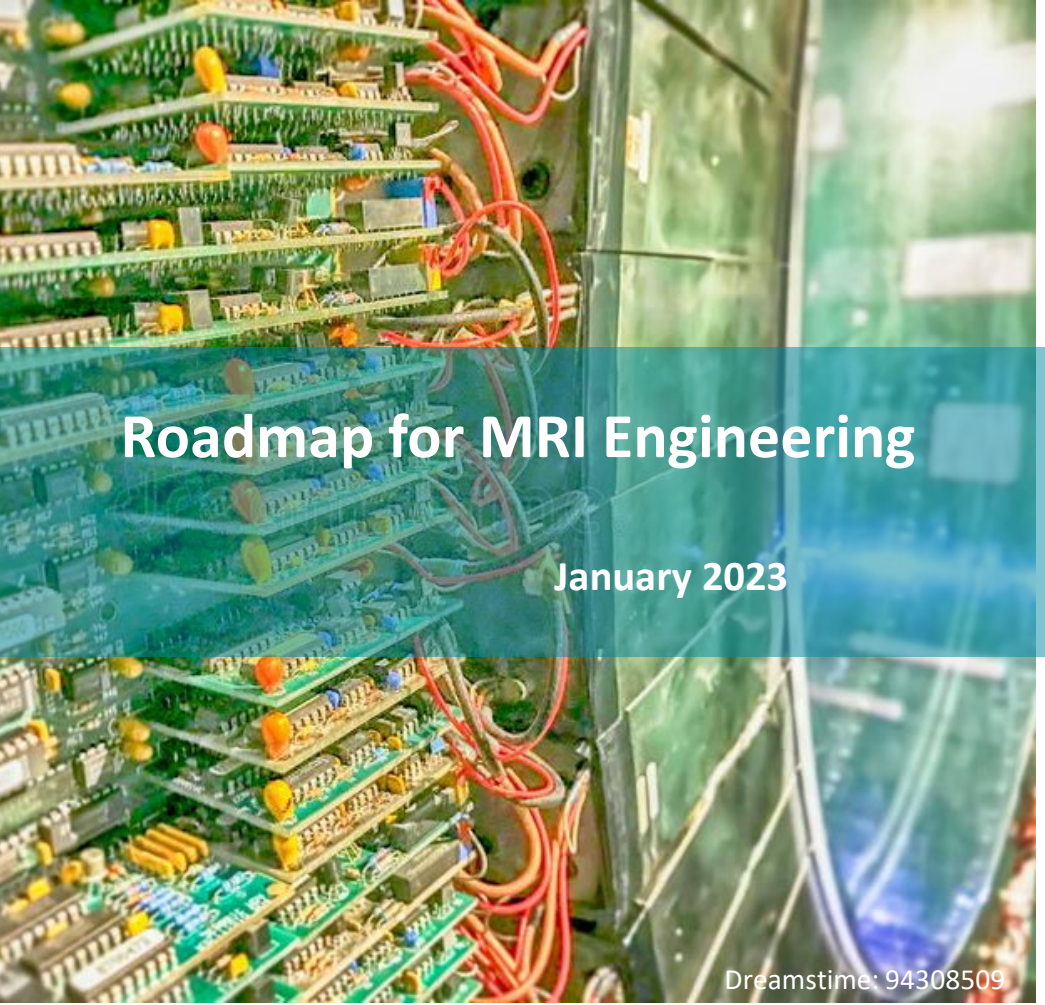

Roadmap for MRI Engineering

January 2023

Dreamstime: 94308509

Departments of Electrical Engineering and Applied Physics

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

C3Te

CENTER FOR CARE & CURE TECHNOLOGY EINDHOVEN

Involved groups and faculty

Sveta Zinger
Signal Processing Systems

Paul Boon
UZ Ghent & Electromagnetics for Care & Cure

Simona Turco
Biomedical Diagnostics Lab

Maarten Paulides
Electromagnetics for Care & Cure & C3Te

Rob Mestrom
Electromagnetics for Care & Cure

Jaap Jansen
MUMC & Signal Processing Systems

Rob Tijssen
CZE Radiotherapy

Irena Zivkovic
Electromagnetics for Care & Cure & Integrated Circuits

Bart van Ark
Prodrive & Electromagnetics

Carola van Pul
MMC & School of Med. Physics & Eng.

Coen Hurkmans
CZE & School of Med. Physics & Eng.

Bas Vermulst
Electromechanics & Power Electronics

Evelien Carrette
UZ Ghent & Electromagnetics for Care & Cure

Massimo Mischi
Biomedical Diagnostics Lab

Debra Rivera
Electromagnetics for Care & Cure & Signal Processing Systems

Bert Aldenkamp
Signal Processing Systems

Themes

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Innovative Hardware/Systems

Rationale: Gains in signal quality and cost effectiveness translate to helping more patients

1-2 yrs *now*

- More efficient power amplifiers (e.g., topology and semiconductor technology; R&D system any field*)
- Hardware development for
  1) Ultra High Field (**7T** , 9.4T)
  2) Multinuclear (7T)
  3) Hyperthermia (1.5T, 3T, 7T)

3-5 yrs *new projects*

- Innovative clinical RF coils (e.g., directive antennas, targeting deep brain at 7T)
- Integrated RF amplifiers with "smart" architectures (e.g., load balanced for integration with RF coils; all field strength R&D)
- Adapting B0 (low field, and real-time B0 shimming arrays in imaging and intervention; all field strength R&D)
- Fully integrated hybrid device (MW hyperthermia, focused ultrasound, radiotherapy; clinical 1.5T, 7T)

5+ yrs *future*

- Multi-center clinical translation of
  1) RF coils and real-time shim systems for personalized medicine (1.5T, 3T, 7T)
  2) Hybrid therapy devices (1.5T 3T, 7T)
- Development and applications of **low field MR** (e.g., compact, leveraging inhomogeneity, perinatology)
- Fully synchronous and interlined amplifiers (e.g., gradient, shimming; all fields)

Image Formation

Rationale: Gains in information content and signal fidelity through AI/multiphysics assimilation

1-2 yrs *now*

- Deep learning-based image reconstruction
- Mathematical models for static and dynamic gradient imperfections
- Near real-time fMRI technology (~1 s)

3-5 yrs *new projects*

- Robust method for synthetic CT generation
- Multi-physics platform for 3D modeling system and signals
- Motion-tracking dynamic B0 shim using real-time AI
- Enhanced Sampling Rate / Real-time (<100 mS) Dynamic Resting State fMRI

5+ yrs *future*

- Clinical translation of emerging techniques
- AI-based tracking of non-rigid motion and prospective voxel adaptation

Informing State-of-Disease

Neurology

Oncology

Rationale: By combining diverse quantitative parameters with AI we can better manage disease

1-2 yrs
now

- Merging model-based and data-driven approaches for disease differentiating
- Ultra High Field MR -- metabolic correlates of aggressiveness in breast cancer
- Resting State fMRI and Neurodynamics (e.g., Accelerated Cog. Aging in epilepsy and Autism)

3-5 yrs
new projects

- "Realtime" feedback fMRI for **identifying and treating** cognitive impairment in epilepsy
- MR-based biomarkers for neuropsychiatric (e.g., depression, OCD, Autism) and degenerative diseases (e.g., Parkinson's and Alzheimer's Disease, MS)
- Multi-parametric MR & (epi)genetic maps to determine tumor aggressiveness/heterogeneity
- Defining Disease States: Multi-modality analysis for mapping molecular signature, vasculature, metabolic state and other biological markers (e.g. epigenetic/genetic, receptor types, tags)

5+ yrs
future

- Quantitative and Multi-parametric MR and multi-modal data fusion (including Neurodynamics)
- Described Disease States for clinic: differential diagnosis, prognosis, and care selection & monitoring

Tailored Therapy

Neurology

Oncology

Rationale: Assessing the accuracy of dosage delivery to the patients

1-2 yrs *now*

- Model-based feedback control
- Receive coil integration into therapy devices
- Image analysis for therapy guidance

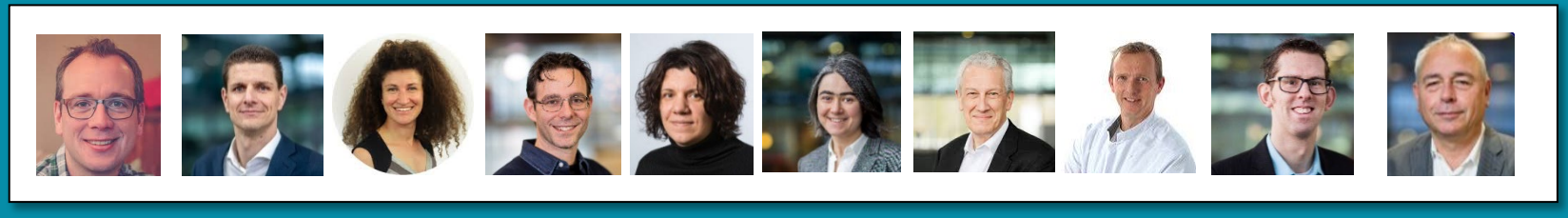
3-5 yrs *new projects*

- Fully integrated hybrid devices (e.g., focused ultrasound, MW hyperthermia, radiotherapy)
- MRI for tissue property imaging (e.g. electrical impedance tomography for fine tuning neurostimulation, quantitative MRI, multi-nuclear MRI)
- Real-time tracking and dosimetry: AI-based segmentation, RT planning adaptation, MR current density imaging, absolute MR thermometry, advanced physiological and metabolic imaging
- Motion-mimicking MRI body phantoms and experimental validation

5+ yrs *future*

- Multi-parametric MRI based therapy planning
- Quantitative real-time MR feedback control
- Clinical translation and evaluation of emerging techniques

Strategic Health Areas – Principal Investigators



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Strategic Health Areas – Medical Application Partners

catharina een santeon ziekenhuis

Maastricht UMC+

UZ GENT

Radboudumc

DANISH RESEARCH CENTRE FOR MAGNETIC RESONANCE

NETHERLANDS CANCER INSTITUTE ANTONI VAN LEEUWENHOEK

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Erasmus MC

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