MSc graduation work at IRCTR

And some background on IRCTR

Synopsis

- IRCTR = fundamental knowledge × cutting edge technology
  - who we are
  - what we do
  - how we do
- MSc^{++}: enjoy your work & build-up your career
- A selection from the current MSc project offer

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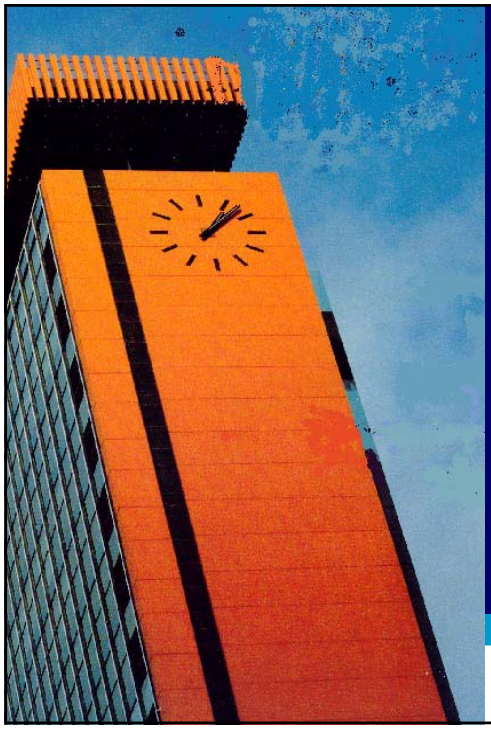
Who we are

International
Research **C**entre for
Telecommunications
and **R**adar



The International Research Centre for Telecommunications and Radar, IRCTR

Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS)

Delft University of Technology

5

TU Delft

TU Delft campus area

Delft Technical University of Technology

- oldest and largest technical university of The Netherlands
- around 13.000 students in 8 faculties
- international Master Courses; language: English
- around 5.000 staff members
- extended laboratories en facilities

6

IRCTR profile

- Research Centre of Delft University of Technology
- Established for project driven research
- Brings applied pre-competitive research to industries and organizations
- Internationalization
- Supported by Dutch Government

IRCTR – general structure

Top performance **T**hrough fundamental knowledge and cutting edge **T**echnology

- Radar
- Ground Penetrating Radar (GPR)
- Antennas/ applied electromagnetics
- Remote Sensing
- Telecommunications – Centre for Wireless Personal Communication
- Radio-navigation

9

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IRCTR – general structure

Top performance **T**hrough fundamental knowledge and cutting edge **T**echnology

- Radar
- Ground Penetrating Radar (GPR)
- Antennas/ applied electromagnetics
- Remote Sensing
- Telecommunications – Centre for Wireless Personal Communication
- Radio-navigation

10

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IRCTR – radar/GPR & antennas

Radar

- Mission statement:

  To understand physical effects (i.e. the propagation and scattering of electromagnetic waves) and the technology required to define, launch, receive, and process waveforms capable of extracting features from the received echoes; the theoretical research is complemented with properly designed experiments, leading to advanced experimental facilities

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IRCTR – radar/GPR & antennas

Radar

- Components:
  - study of frequency and/or phase modulated waveforms, e.g. frequency and polarization agility ➡ high spatial resolution + multi-parameter descriptors of objects
  - future applications: a radar that operates as a communication device by coding its waveform

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IRCTR – radar/GPR & antennas

Ground penetrating radar (GPR)

- Mission statement:

  The development of Ultra-Wideband (UWB) technology for detection, ranging, positioning and classification of targets

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IRCTR – radar/GPR & antennas

Ground penetrating radar (GPR)

- Components:
  - ground penetrating radar: video impulse GPR and a stepped frequency continuous wave (SFCW) radar
  - UWB radar for human beings detection
  - UWB positioning and communications
  - improved GPR-antennas (including adaptive antennas)
  - new methods of subsurface imaging based on interferometry and polarimetry
  - the development of classification algorithms

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IRCTR – radar/GPR & antennas

Antennas/ applied electromagnetics

- Mission statement:

  To create a bridge between the people involved in the theoretical investigations and those focusing on experimental validation

  Eng goal: to master the complete chain: model ➡ analysis + optimisation ➡ physical implementation ➡ measurement

15

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IRCTR – radar/GPR & antennas

Antennas/ applied electromagnetics

- Components:
  - development of models (focus on time-domain approaches)
  - identifying the most adequate computational techniques to be employed for the analysis and optimisation of antennas
  - understanding the technological requirement for manufacturing them
  - streamlining the measurement methodologies

16

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IRCTR – remote sensing

Atmospheric radar remote sensing

- Mission statement:

  To develop new tools and methodologies for the observation of atmospheric phenomena with the aim to enhance the understanding of meteorological processes and to improve climate predictions

IRCTR – remote sensing

Atmospheric radar remote sensing

- Components:
  - electromagnetic scattering
  - sensor synergy
  - signal processing
  - radar technology

IRCTR – remote sensing

Radar earth observation

- Mission statement:

  The development of new Synthetic Aperture Radar (SAR) technologies, be it for observation from space or the air

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IRCTR – remote sensing

Radar earth observation

- Components:
  - frequency-modulated, continuous-wave (FM-CW) radar based systems
  - P-band SAR systems
  - enhanced information extraction from radar data, for instance through radar signature studies and simulation
  - new applications in high-resolution and/or polarimetric imaging, moving-target indication and wind vector determination over water surfaces

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IRCTR – research activities

- Strategic research objectives:
  - radar
  - wireless communication
- Work philosophy:
  - large research programmes, often encompassing more specific projects
  - dedicated (smaller scale) projects
  - own initiatives ➡ highly innovative domains
  - participation in wide international consortia

Projects – radar & GPR

Advanced Re-Locatable Multi-Sensor System for Buried Landmine Detection:

- time span: 1999-2006
- result: 2 operational radars
- One impulse radar and one SFCW radar

23

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Projects – radar for atmospheric research

The transportable radar system for atmospheric measurements – TARA:

- based on the FM-CW radar principle
- measures clouds and precipitation as well as clear-air turbulence
- operational since 2001

24

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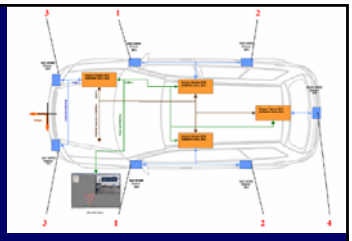

UWB radar

25

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Projects – agile radar

PARSAX

Polarimetric Agile Radar in S- And X-band

System Design and manufacturing of a Radar Allowing simultaneous BSM estimation of Non-stable Objects

26

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Projects – agile radar

The PARSAX radar developed in the project will be used for testing and validating a new method to separate targets and clutter by using polarimetric properties of backscattered radar signals.

- **Generate and apply the orthogonal coded signals.**
- **Research on scattering fundamentals and experimental verifications by realizing a dual-transmit / dual-receive radar.**

1. Generation of orthogonal coherent signals with a large BT product and 50MHz spectrum width in the 2 frequency bands. -60dB spurious level.
   (S-band, 3315+/-25MHZ and X-band, [9700~10000]+/-25MHZ).
2. Coherent digital processing of the received signals in at least 70dB dynamic range for signal spectrum width > 50MHz.
3. Zoom mode for the X-band extension (300MHz sweep generated for high resolution mode).

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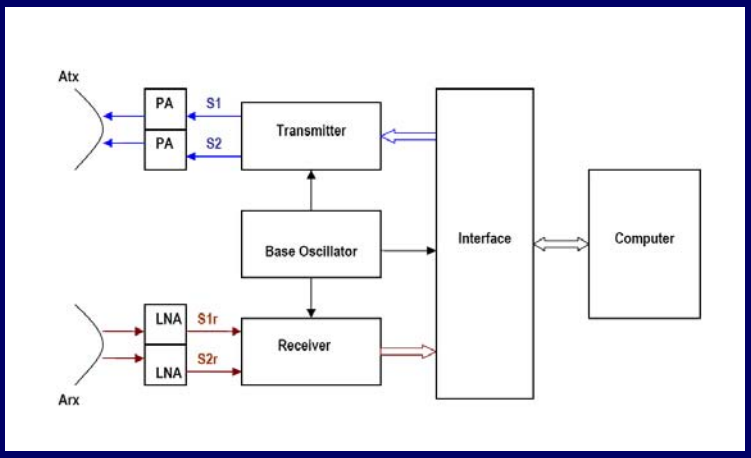
Projects – agile radar

Block diagram of polarization radar



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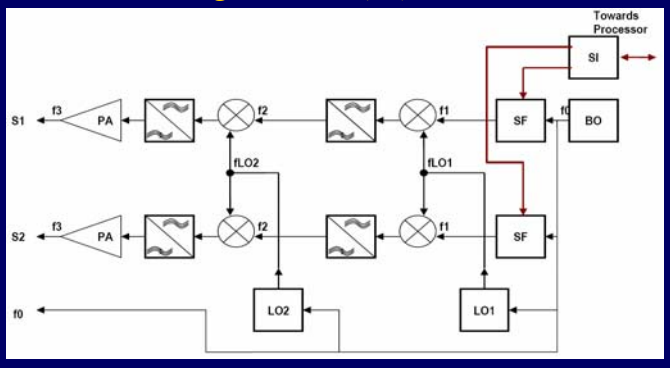
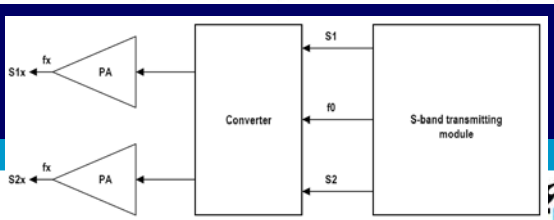
Functional diagram of S-(X-)band transmitter





29

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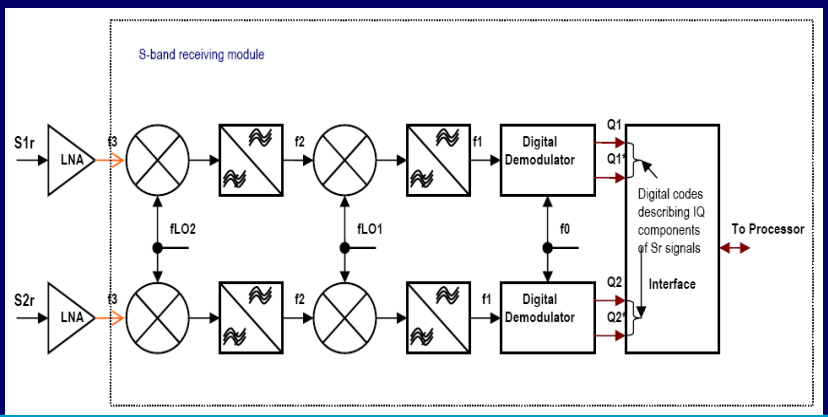
Projects – agile radar

Functional diagram of S-(X-)band receiver



30

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Parameters of PARSAX radar signals

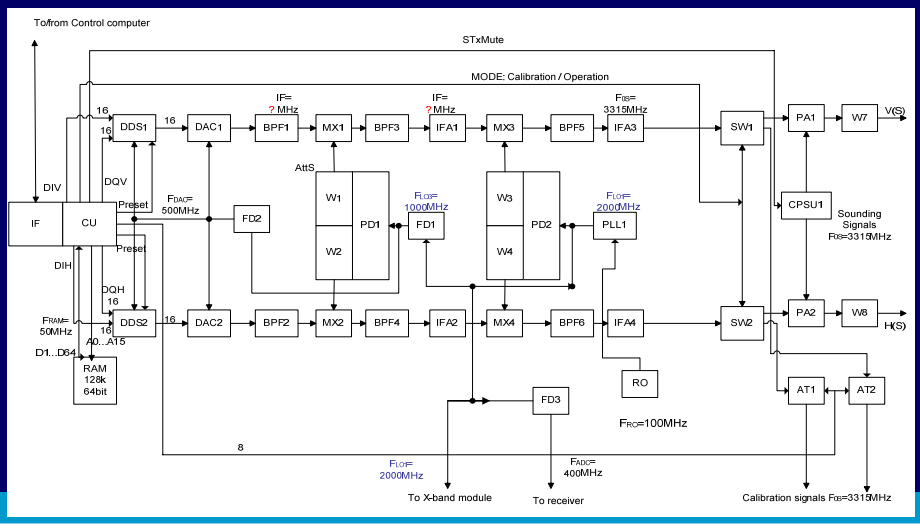
Parameters	Weather objects sounding	
	PCM signal	LFM signal
Carrier frequency	3315 MHz	
Peak transmitted power	80–100 W	
Signal energy	100 mJ	
Signal type	PCM signal modulated by M-sequence	LFM signal (saw-tooth modulation)
Sequence length	65535	-----
Duration of the sequence's element	20 ns	-----
Frequency deviation	-----	50 MHz
Signal spectrum width	50 MHz	
Signal duration	1310.7 μs	1310.7 μs
Repetition frequency	763 Hz	763 Hz
Maximum ambiguous range	195 km	195 km
BT-product	65535	65535
Range resolution	3m	3m
Number of integration periods for Doppler processing	512	512
Doppler velocity resolution	0.07 m/s	0.07 m/s
Integration time	671ms	671ms

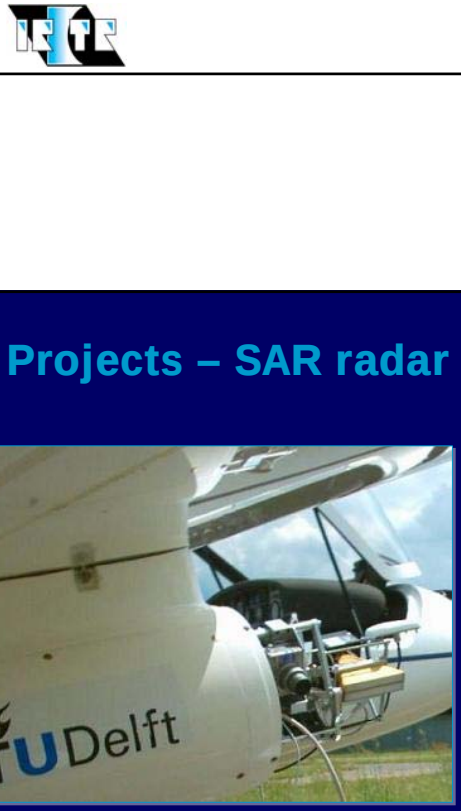
Projects – agile radar

- **Signals generation**
  - Generation of codes sequence (I-Q quadratures) by means of DDS
  - DAC transformation into two analogue signals
  - Generation of modulated oscillators by means of analogue quadrature modulator
- **Algorithm of reception**
  - Transformation of RF oscillation into codes stream as a result of time and amplitude sampling by fast ADC
  - Estimation of the signal complex envelope described by pairs of IQ-components

32

Projects – agile radar

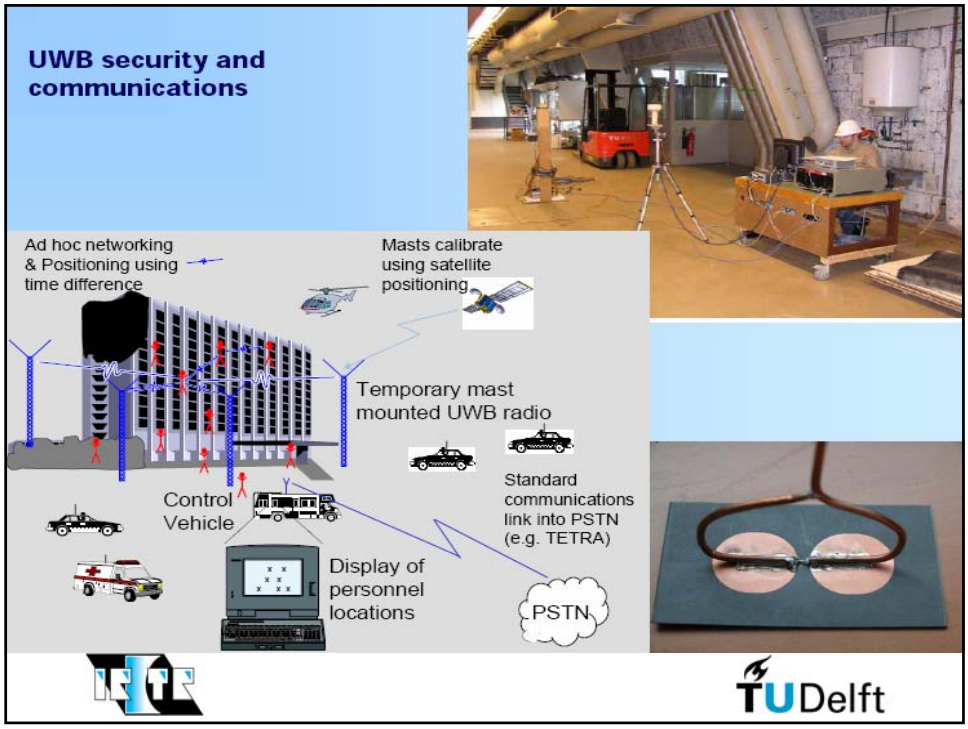




Projects – SAR radar

Airborne Ka-Band FM-CW SAR System:

- low-cost imaging radar systems of high resolution
- operation from very small, possibly even unmanned, airborne platforms


UWB security and communications
Ad hoc networking & Positioning using time difference
Masts calibrate using satellite positioning
Temporary mast mounted UWB radio
Standard communications link into PSTN (e.g. TETRA)
Control Vehicle
Display of personnel locations
PSTN
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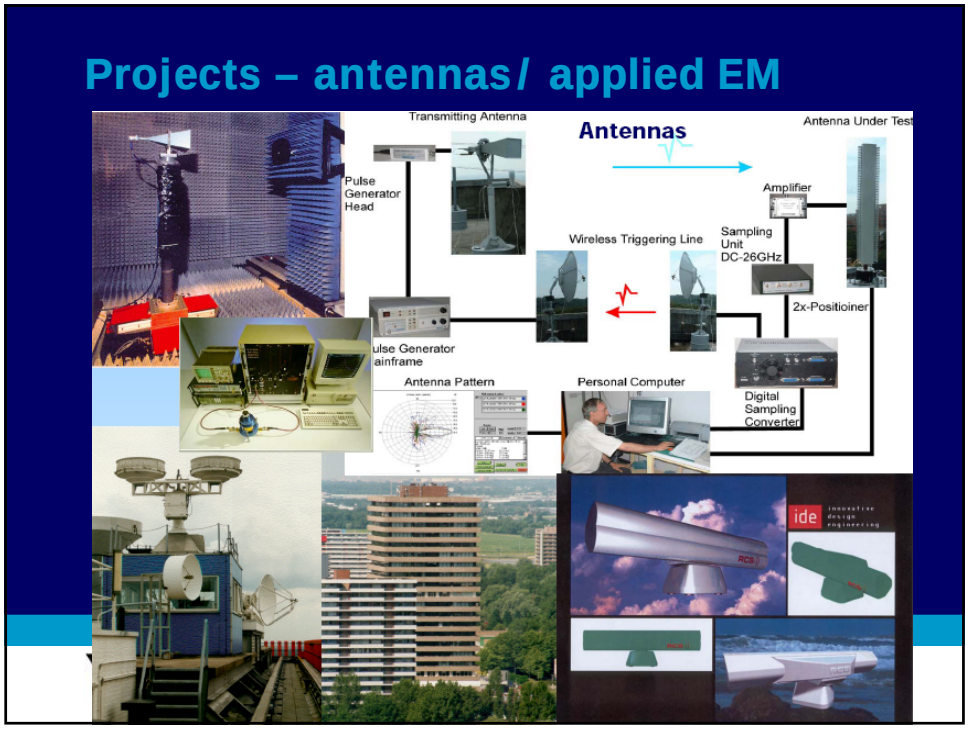
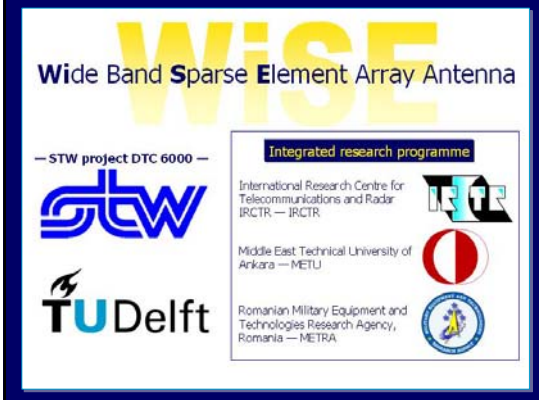

Projects – antennas/ applied EM
Antennas
Transmitting Antenna
Antenna Under Test
Pulse Generator Head
Amplifier
Sampling Unit DC-26GHz
Wireless Triggering Line
2x-Positioiner
Antenna Pattern
Personal Computer
Digital Sampling Converter

Projects – antennas/ applied EM



Wide Band Sparse Element Array Antenna (WiSE):

- elementary radiators design
- non-periodic placement + interleaving
- manufacturing
- measurement

37

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Projects – antennas/ applied EM

Wide Band Sparse Element Array Antenna (WiSE):

- elementary radiators design
- non-periodic placement + interleaving
- manufacturing
- measurement

38

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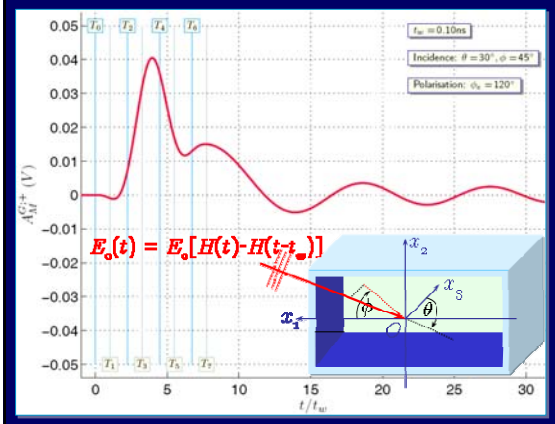
Projects – antennas/ applied EM



Time-domain investigation of antenna systems:

- the pulsed-field multiport antenna system reciprocity relation by means of a time-domain approach

39

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Projects – remote sensing

New radar system for the study of light rain:

- system design
- signal processing
- observation strategies

40

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Projects – remote sensing

Radar observation studies:

- data processing
- data analysis
- image processing

41

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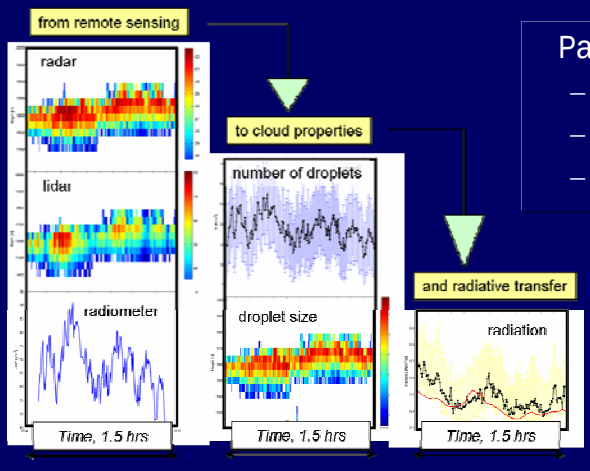
Projects – remote sensing



Parameter estimation:

- sensor fusion
- retrieval techniques
- application

42

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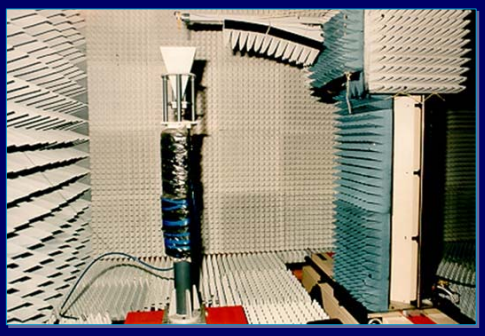
The staff

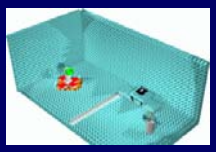
- 3 Professors
- 2 Associate Professors
- 3 Assistant Professors
- 11 supporting/ technical staff
- 17 PhD students

A united, well honed TEAM

Measurement facilities

- Delft University Chamber for Antenna Test (DUCAT)





45

Measurement facilities

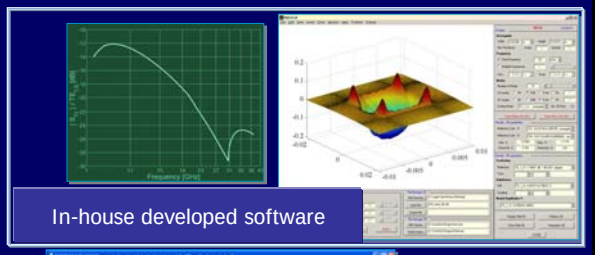
- Millimetre wave measurement facilities

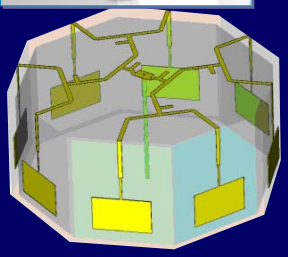
Hewlett-Packard network vector analyzer
up to 110 GHz

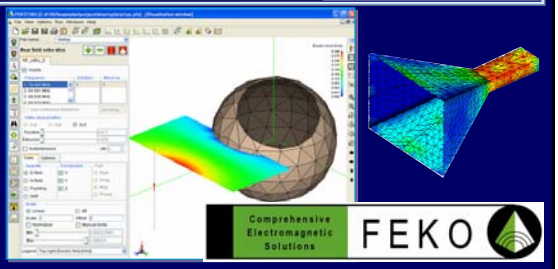
ABmm network vector analyzer
up to 350 GHz

46

Software resources







47

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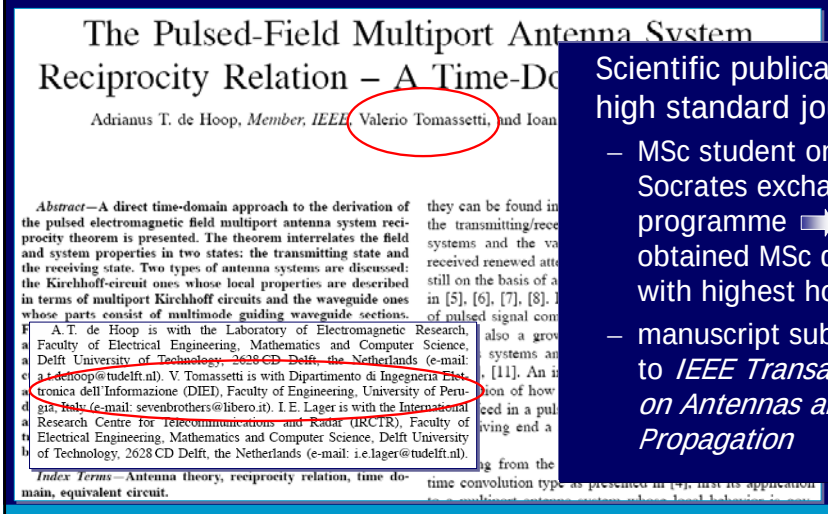
The work environment

- IRCTR – a highly international construction:
  - multi-national staff
  - many visiting/ exchange students
  - frequent visits of reputed scientists
- Interested in placements abroad? ➡ Make use of our international network of collaborations
- Direct access to measurement facilities

We help you build-up your CV


The Pulsed-Field Multiport Antenna System Reciprocity Relation – A Time-Do

Adrianus T. de Hoop, *Member, IEEE*, Valerio Tomassetti, and Ioan

***Abstract*—A direct time-domain approach to the derivation of the pulsed electromagnetic field multiport antenna system reciprocity theorem is presented. The theorem interrelates the field and system properties in two states: the transmitting state and the receiving state. Two types of antenna systems are discussed: the Kirchhoff-circuit ones whose local properties are described in terms of multiport Kirchhoff circuits and the waveguide ones whose parts consist of multimode guiding waveguide sections.**

A. T. de Hoop is with the Laboratory of Electromagnetic Research, Faculty of Electrical Engineering, Mathematics and Computer Science, Delft University of Technology, 2628 CD Delft, the Netherlands (e-mail: a.t.dehoop@tudelft.nl). V. Tomassetti is with Dipartimento di Ingegneria Elettronica dell'Informazione (DIEI), Faculty of Engineering, University of Perugia, Italy (e-mail: sevenbrothers@libero.it). I. E. Lager is with the International Research Centre for Telecommunications and Radar (IRCTR), Faculty of Electrical Engineering, Mathematics and Computer Science, Delft University of Technology, 2628 CD Delft, the Netherlands (e-mail: i.e.lager@tudelft.nl).

***Index Terms*—Antenna theory, reciprocity relation, time domain, equivalent circuit.**

they can be found in
the transmitting/rece
systems and the va
received renewed att
still on the basis of a
in [5], [6], [7], [8].
of pulsed signal com
also a grow
systems an
, [11]. An i
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g from the
time convolution type as presented in [4], first its application

Scientific publications in high standard journals:

- MSc student on a Socrates exchange programme ➡ obtained MSc degree with highest honours
- manuscript submitted to *IEEE Transactions on Antennas and Propagation*

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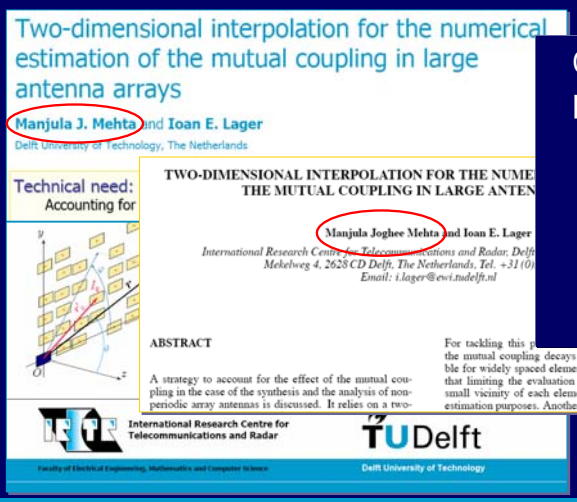
Two-dimensional interpolation for the numerical estimation of the mutual coupling in large antenna arrays

Manjula J. Mehta and Ioan E. Lager

Delft University of Technology, The Netherlands

Technical need:
Accounting for

TWO-DIMENSIONAL INTERPOLATION FOR THE NUME
THE MUTUAL COUPLING IN LARGE ANTEN

Manjula Joghee Mehta and Ioan E. Lager

International Research Centre for Telecommunications and Radar, Delft
Mekelweg 4, 2628 CD Delft, The Netherlands, Tel. +31 (0)
Email: i.lager@ewi.tudelft.nl

ABSTRACT

A strategy to account for the effect of the mutual coupling in the case of the synthesis and the analysis of non-periodic array antennas is discussed. It relies on a two-

For tackling this p
the mutual coupling decays quickly, becoming negligible for widely spaced elements. It was then conjectured that limiting the evaluation of this effect to a sensibly small vicinity of each element will suffice, at least for estimation purposes. Another useful result emerged from

International Research Centre for Telecommunications and Radar

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Delft University of Technology

Faculty of Electrical Engineering, Mathematics and Computer Science

Conference proceeding publications:

- accepted full paper at the 1st European Conference on Antennas and Propagation, EuCAP 2006, Nice

51

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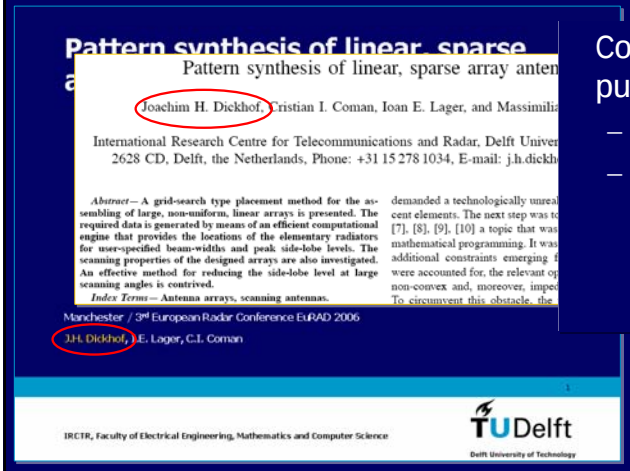
Pattern synthesis of linear, sparse

Pattern synthesis of linear, sparse array anten

Joachim H. Dickhof, Cristian I. Coman, Ioan E. Lager, and Massimili

International Research Centre for Telecommunications and Radar, Delft Univer
2628 CD, Delft, the Netherlands, Phone: +31 15 278 1034, E-mail: j.h.dickh

Abstract— A grid-search type placement method for the assembling of large, non-uniform, linear arrays is presented. The required data is generated by means of an efficient computational engine that provides the locations of the elementary radiators for user-specified beam-widths and peak side-lobe levels. The scanning properties of the designed arrays are also investigated. An effective method for reducing the side-lobe level at large scanning angles is contrived.

Index Terms— Antenna arrays, scanning antennas.

demanded a technologically unreal
cent elements. The next step was to
[7], [8], [9], [10] a topic that was
mathematical programming. It was
additional constraints emerging f
were accounted for, the relevant op
non-convex and, moreover, imped
To circumvent this obstacle, the

Manchester / 3rd European Radar Conference EuRAD 2006

J.H. Dickhof, I.E. Lager, C.I. Coman

IRCTR, Faculty of Electrical Engineering, Mathematics and Computer Science

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Delft University of Technology

Conference proceeding publications:

- accepted full paper
- presentation at the 3rd European Radar Conference, EuRAD 2006, Manchester

52

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MSc projects – radar

- Title of the project: New waveforms for Radar -1
- Subtitle: Digital matched filtering of the FMCW signals – an FPGA based approach
- Tutor: Dr O. Krasnov
- Professor: Prof. P. van Genderen
- Description of the project:

  To develop, model and optimize the FPGA based implementation of the real time algorithm for the polarimetric FMCW radar

MSc projects – radar

- Title of the project: New waveforms for Radar -2
- Subtitle: Optimal orthogonal PCM codes for the PARSAX polarimetric radar
- Tutor: Dr O. Krasnov
- Professor: Prof. P. van Genderen
- Description of the project:

  The modelling, analysis and selection of the pairs of codes with a given length, which are optimal for the best orthogonality in the whole predefined range of time delays

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MSc projects – radar

- Title of the project: Design of the hardware circuits for the real-time calibration of the polarimetric PARSAX radar
- Tutor: Dr O. Krasnov
- Professor: Prof. P. van Genderen
- Description of the project:

  To develop, model and analyse the interchannel transmitter synchroniser and calibration circuits

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MSc projects – antennas / applied EM

- Title of the project: Pulsed electromagnetic wave propagation along a closed waveguide – A pulse distortion analysis
- Supervisor: Dr.ing. I. E. Lager
- Scientific advisor: Prof.Dr.Ir. A.T. de Hoop (emeritus professor, Lorentz chair)
- Description of the project:

  The explored topic is highly innovative; the contents is primarily theoretic, but has a large applicative potential

57

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MSc projects – antennas / applied EM

- Title of the project: Pulsed-field smart antenna systems analysis
- Supervisor: Dr.ing. I. E. Lager
- Scientific advisor: Prof.Dr.Ir. A.T. de Hoop (emeritus professor, Lorentz chair)
- Description of the project:

  The explored topic is highly innovative; the investigations focus on the development of theoretical models; the application area can be found in the impulse radio (an extremely hot topic in communications)

58

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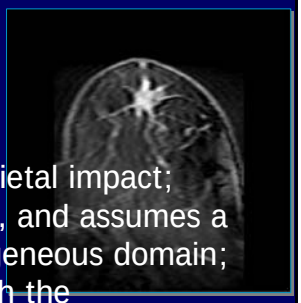
MSc projects – antennas / applied EM

- Title of the project: Electromagnetic detection and ablation of female breast cancer
- Supervisor: Dr.Ir. B. J. Kooij
- Scientific advisor: Dr.ing. I. E. Lager
- Description of the project:

  The explored topic has a very high societal impact; the project concerns a feasibility study, and assumes a numerical analysis of a highly inhomogeneous domain; the project is part of a cooperation with the Universitair Medisch Centrum Utrecht

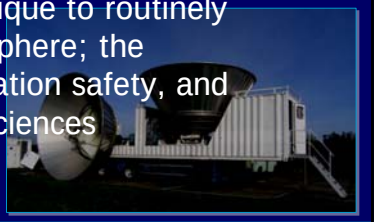


59

MSc projects – remote sensing

- Title of the project: Signal processing for a turbulence radar
- Supervisor: Dr H. Russchenberg
- Scientific/technical advisor: C. Unal
- Description of the project:

  IRCTR is developing a new technique to routinely measure turbulence in the atmosphere; the information can be applied in aviation safety, and more generally: in atmospheric sciences

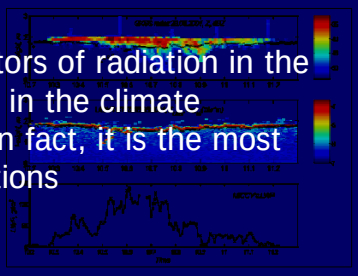


60

MSc projects – remote sensing

- Title of the project: Space-based radar observations of clouds
- Supervisor: Dr H. Russchenberg
- Scientific/ technical advisor: Dr O. Krasnov
- Description of the project:

  Clouds are very important regulators of radiation in the atmospheres; however, their role in the climate systems is far from understood; in fact, it is the most unsure element in climate predictions



61