TU Delft

Microwave Sensing, Signals and Systems (MS^3) group

Department of Microelectronics

Faculty of Electrical Engineering, Mathematics and Computer Science

Topics for research MSc projects

Delft - 2019

Note

If you did not find in this booklet a topic that is interesting for you, visit any faculty member of the MS3 group for your interests discussion.

We have much more ideas to research!

THALES

www.thalesgroup.com

MSc thesis projects at Thales Nederland B.V.

LOCATION *DELFT*

Thales Nederland is active in the Defense and Security sectors and is, with more than 2000 employees, a top provider of high-tech jobs. Product innovation and swift anticipation of the newest technological possibilities are the mainsprings of our business. Examples are radar, communication and command & control systems for naval ships and communication, security and payment systems for trade and industry.

Thales Nederland is part of the Thales Group, which has a workforce of over 68.000 in more than 50 countries making it one of Europe's largest electronics companies.

Thales Delft is a small R&D site of Thales Nederland close to TU Delft, and it offers a limited number of MSc thesis projects focusing on radar. The thesis assignments are formulated in detail together with the student and his/her university mentors.

THEME 1: <u>Advanced techniques to measure and exploit target signatures</u>

Modern radar systems have increased flexibility and capacity with respect to beamforming, waveforms, resource allocation management and signal processing. This flexibility opens up new radar capabilities that exploit the additional information that can be obtained from the objects of interest, i.e. the 'targets'. For instance, by spending more measuring time on a target, details in the Doppler return, i.e. the micro-Doppler signature of a target, can be obtained. This signature holds information on the shape of the object and on oscillating or rotating parts on the body of the object. Combined with novel signal processing techniques and state of the art machine (deep) learning, advanced radar applications can be investigated.

This assignment considers a framework that learns the signature of different objects in either a supervised or an unsupervised fashion. The objective is to investigate how well different objects can be learned/recognized, depending on the radar wavelength and the complexity of the objects. The assignment initially focuses on synthetically generated signatures, but may include lab measurements to validate the concept.

In a later stage, polarimetric properties may be included to further improve the performance of the setup.

To apply for an internship, please contact:
<u>denis.riedijk@nl.thalesgroup.com</u>

OPEN

THALES

www.thalesgroup.com

MSc thesis projects at Thales Nederland B.V.

LOCATION *DELFT*

Thales Nederland is active in the Defense and Security sectors and is, with more than 2000 employees, a top provider of high-tech jobs. Product innovation and swift anticipation of the newest technological possibilities are the mainsprings of our business. Examples are radar, communication and command & control systems for naval ships and communication, security and payment systems for trade and industry.
Thales Nederland is part of the Thales Group, which has a workforce of over 68.000 in more than 50 countries making it one of Europe's largest electronics companies.
Thales Delft is a small R&D site of Thales Nederland close to TU Delft, and it offers a limited number of MSc thesis projects focusing on radar. The thesis assignments are formulated in detail together with the student and his/her university mentors.

THEME 2: Advanced techniques to mitigate clutter and improve target detection

Modern radar systems have increased flexibility and capacity with respect to beamforming, waveforms, resource allocation management and signal processing. This flexibility opens up new radar capabilities that exploit the additional information that can be obtained from radar measurements.

One assignment considers replacing conventional radar signal processing algorithms with machine learning (ML) versions. An ML version then mimics the original algorithm, but has deviating behavior that gives improved results where the conventional method underperforms. A typical example of this could be the Constant False Alarm Rate, or CFAR algorithm that normally does not adapt to varying clutter statistics. The assignment initially focuses on synthetically generated data, but may include real life measurements to validate the concept.

Another assignment considers removing known (learned) clutter types from 'polluted' signature measurements, e.g. in micro-Doppler, by using state of the art deep learning techniques, such as generative adversarial networks (GANs). A typical example is the removal of wind turbine clutter from a small drone signature, when the drone is flying near a wind farm.

Both assignments embark on previously performed research.

To apply for an internship, please contact:
denis.riedijk@nl.thalesgroup.com

OPEN

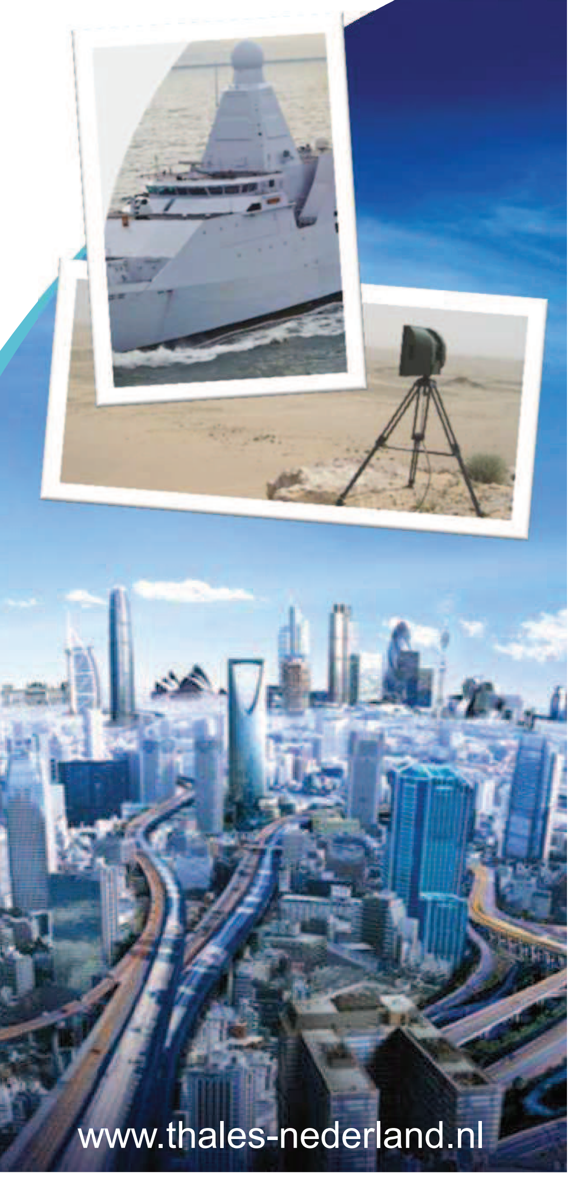
MSc thesis projects at Thales Nederland B.V.

LOCATION *DELFT*

Thales Nederland is active in the Defense and Security sectors and is, with more than 2000 employees, a top provider of high-tech jobs. Product innovation and swift anticipation of the newest technological possibilities are the mainsprings of our business. Examples are radar, communication and command & control systems for naval ships and communication, security and payment systems for trade and industry.
Thales Nederland is part of the Thales Group, which has a workforce of over 68.000 in more than 50 countries making it one of Europe's largest electronics companies.
Thales Delft is a small R&D site of Thales Nederland close to TU Delft, and it offers a limited number of MSc thesis projects focusing on radar. The thesis assignments are formulated in detail together with the student and his/her university mentors.

THEME 3: Information-based Processing in Radar: Compressive Sensing and Information Geometry

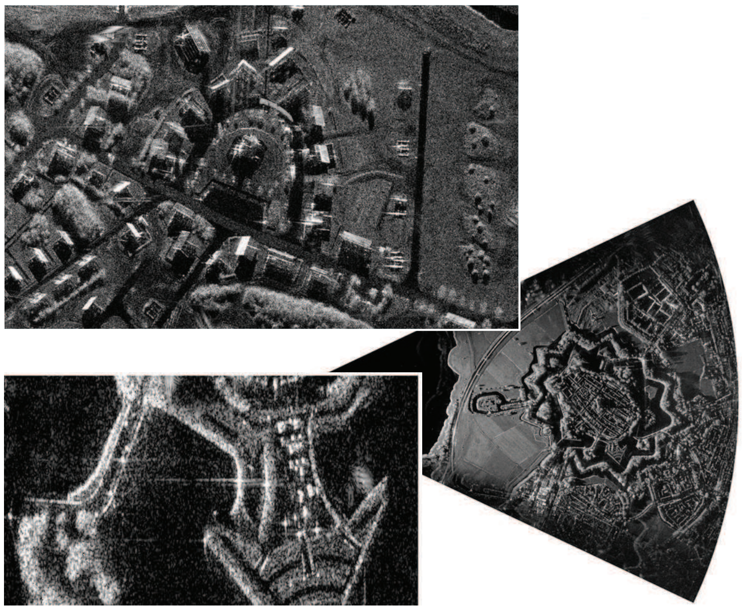
Compressive Sensing (CS) is a recent paradigm in sensing that works with a reduced number of measurements for a comparable sensing result. Promising benefits of CS in radar are improved resolution and multi-target analysis.
Information geometry (IG) is an approach to stochastic signal processing whose structures can be treated as structures in differential geometry. Most promising benefits of IG have been found in resolution analysis and parameter estimation.
Both fields stress the importance of information in measurements as the useful dimension of signals is much smaller than the data dimensionality. Accordingly, conventional processing can be improved if the demands of data acquisition and signal processing are optimized to the information content. Tools from CS and IG can also be used in development of deep learning in order to improve the stochastic analysis of the underlying processing layers.
.

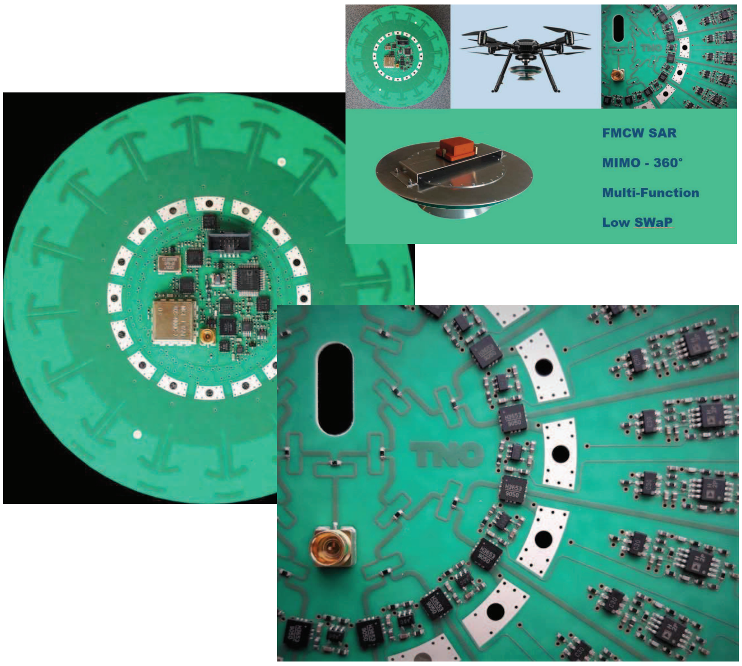


To apply for an internship, please contact:
denis.riedijk@nl.thalesgroup.com

Agile Radar System for Drones

Synthetic Aperture Radar (SAR) is a high-resolution radar imaging technique used in airborne and spaceborne radars. TNO has developed a miniaturised SAR system that is circular in design, weighs only 800 grams and can be mounted on a small drone. This digital 32-channel radar system is a unique system that is at the very forefront of drone radar developments. Its inherent flexibility allows for many novel and innovative radar modes to be conceived and demonstrated. Thus advanced signal processing techniques for various new detection and imaging modes need to be developed and implemented, including image processing tools for new types of radar imagery such as wide-angle multi-aspect image sets. In addition, suitable motion compensation and navigation methods have to be developed and tested. Depending on your interests, the work may also include application of compressive sensing or machine learning techniques.





Possible research topics include:

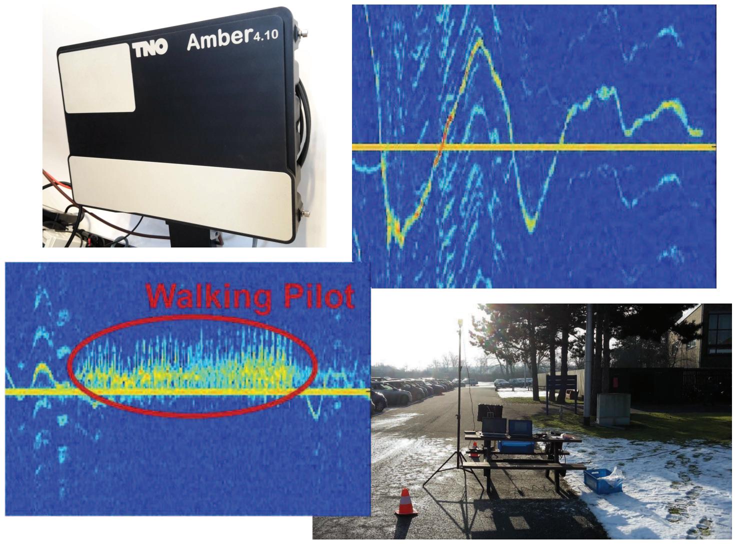
- assessment of new radar operating modes
- advanced radar imaging
- compensation of motion in signal processing
- application of advanced processing methods like compressive sensing or machine learning
- accurate navigation methods
- inverse synthetic aperture radar

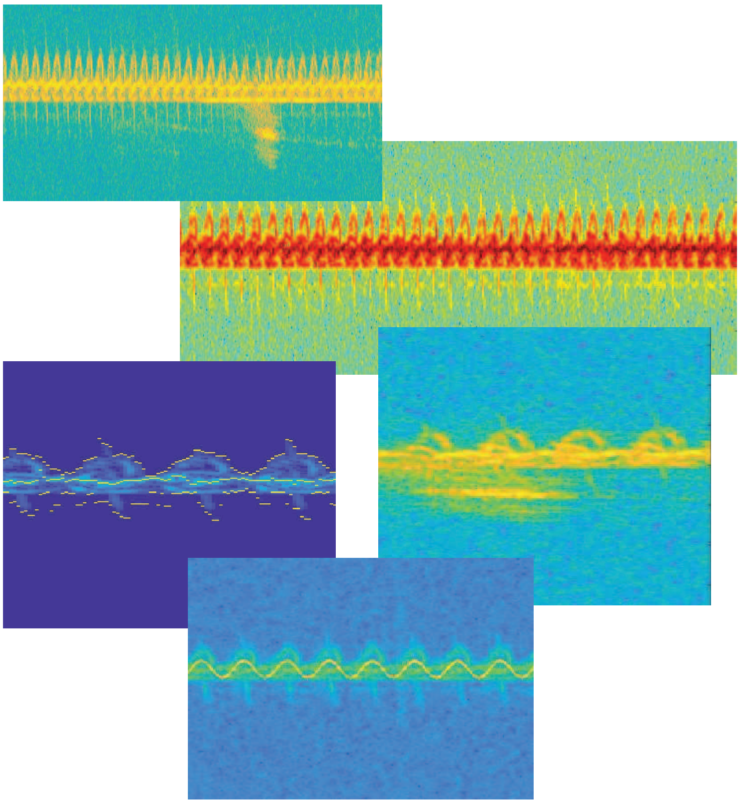
TNO innovation for life

Contact: Jacco de Wit, TNO Department of Radar Technology
Visit: www.tno.nl for more information about internships and graduation projects

Classification of Radar Micro-Doppler Signatures

The radar micro-Doppler signature of an object is determined by parts rotating or moving in addition to the motion of the object as a whole, think for example of a rotating aircraft propeller. Radar micro-Doppler signatures are specific for different types of objects and can therefore be used for object classification. One example is the micro-Doppler characterisation of human motion. The way of walking, the torso motion and the swinging of the arms (or not) of a person may indicate whether that person is carrying a heavy item or backpack.





The goal of this assignment is to develop and test innovative micro-Doppler feature extraction and classification methods. One line of investigation may be the development of tangible, physically meaningful features. The robustness and distinctiveness of these features can be tested using for instance a support vector machine classifier. Another line of investigation may be the application of neural networks for classification. This line of investigation includes visualization techniques to gain insight in the actual operation of neural networks by highlighting the activation areas within the radar micro-Doppler signatures. Some representative data sets of walking people and drones are readily available. However, the work may include conducting additional measurements to test your results.

Possible research topics include:

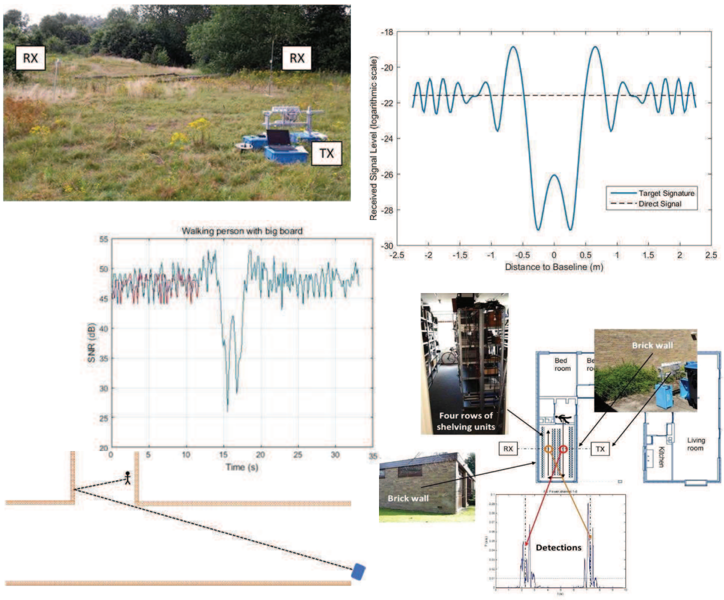
- machine learning for classification
- multimodal learning
- autoencoders
- feature extraction

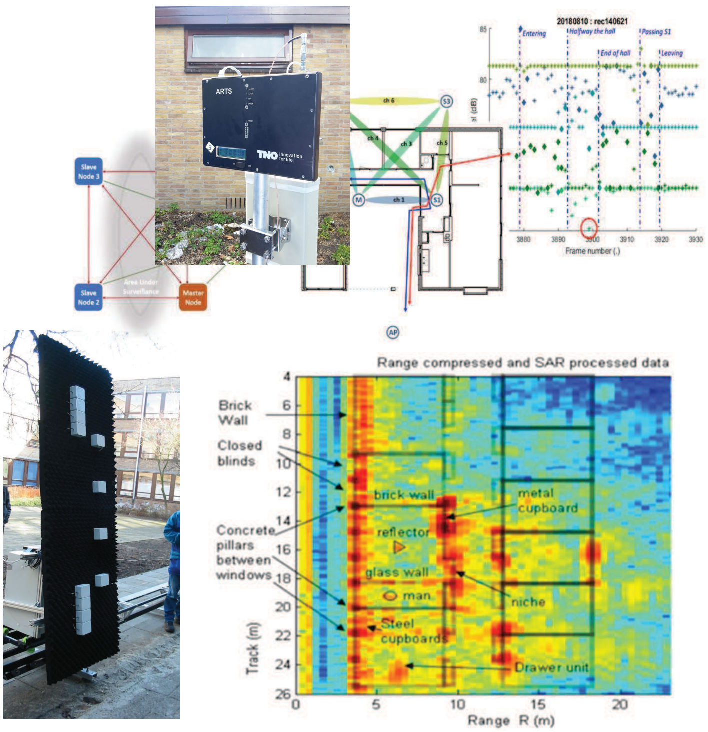
TNO innovation for life

Contact: Jacco de Wit, TNO Department of Radar Technology
Visit: www.tno.nl for more information about internships and graduation projects

Urban and Through-Wall Radar Surveillance

In the urban environment radar observations are obstructed by buildings, fences and other obstacles. Due to these obstacles a large part of the area under observation may be shielded from the radar and false detections may occur due to multipath. Innovative signal processing methods are needed to enhance the radar observations. One line of investigation in this area is the exploitation of multipath reflections. Another line of investigation is the deployment of a network of radar sensors observing the area from different sides, possibly exploiting the forward scattering radar principle.

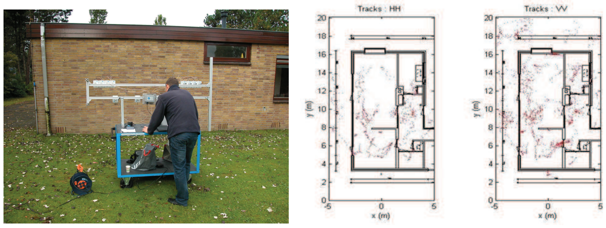




In the urban environment, covert surveillance of building interiors is also an important asset. Through-wall radars are being developed which focus on obtaining building lay-outs and/or on the detection of people inside a building. A new approach to detecting people inside a building is forward scattering. TNO has developed several radars for through-wall sensing. These systems will be used to perform several experiments to record both forward scatter and backscatter radar data. These recordings will be used off-line to fine tune and optimise a tracker (i.e., a data fusion engine to track people over time) or design a new tracker that can combine these different types of observations. The goal is to track moving people inside a building using radar technology.

Possible research topics include:

- multistatic tracking
- “around the corner” radar
- through-wall radar
- forward scatter radar



innovation for life

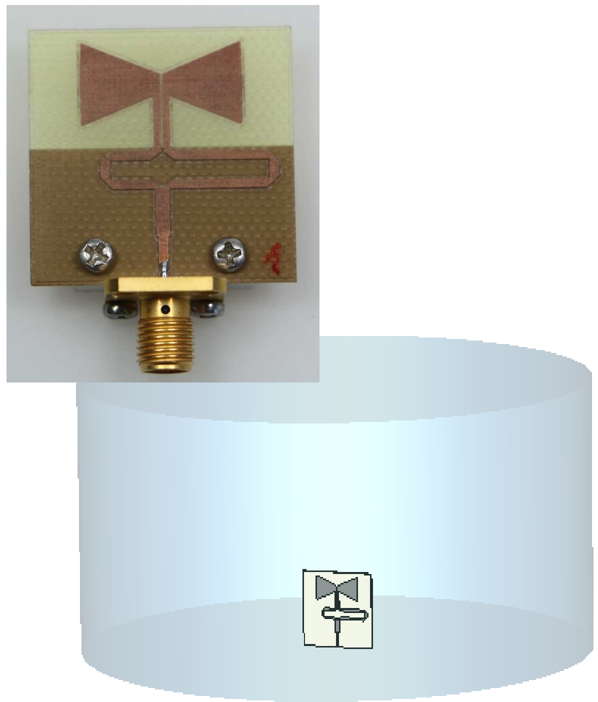
Contact: Jacco de Wit, TNO Department of Radar Technology
Visit: www.tno.nl for more information about internships and graduation projects

Measurement techniques for efficient determination of the radiation efficiency of single antenna elements

Contact: Dr. Frank Weinmann, frank.weinmann@fhr.fraunhofer.de, +49 228 9435-223

Internship / student research project / Bachelor Thesis / Master Thesis:

- Literature research on existing methods for estimation of radiation efficiency
- Evaluation of these methods with respect to practical implementatioan for measuring the radiation efficiency of single antenna elements
- Development of a demonstrator and a broadband test antenna
- Test Measurements
- Study of methods for evaluation of measurement data in the case of resonant modes
- Optimization of the demonstrator set-up



TU Delft Contact person: Prof. Alexander Yarovoy (A.Yarovoy@tudelft.nl)

AESA Weather Radar. Array Calibration

Contact: Dr. Stefano Turso, stefano.turso@fhr.fraunhofer.de, +49 228 9435-136

Limitations of current weather radars are quite notable:

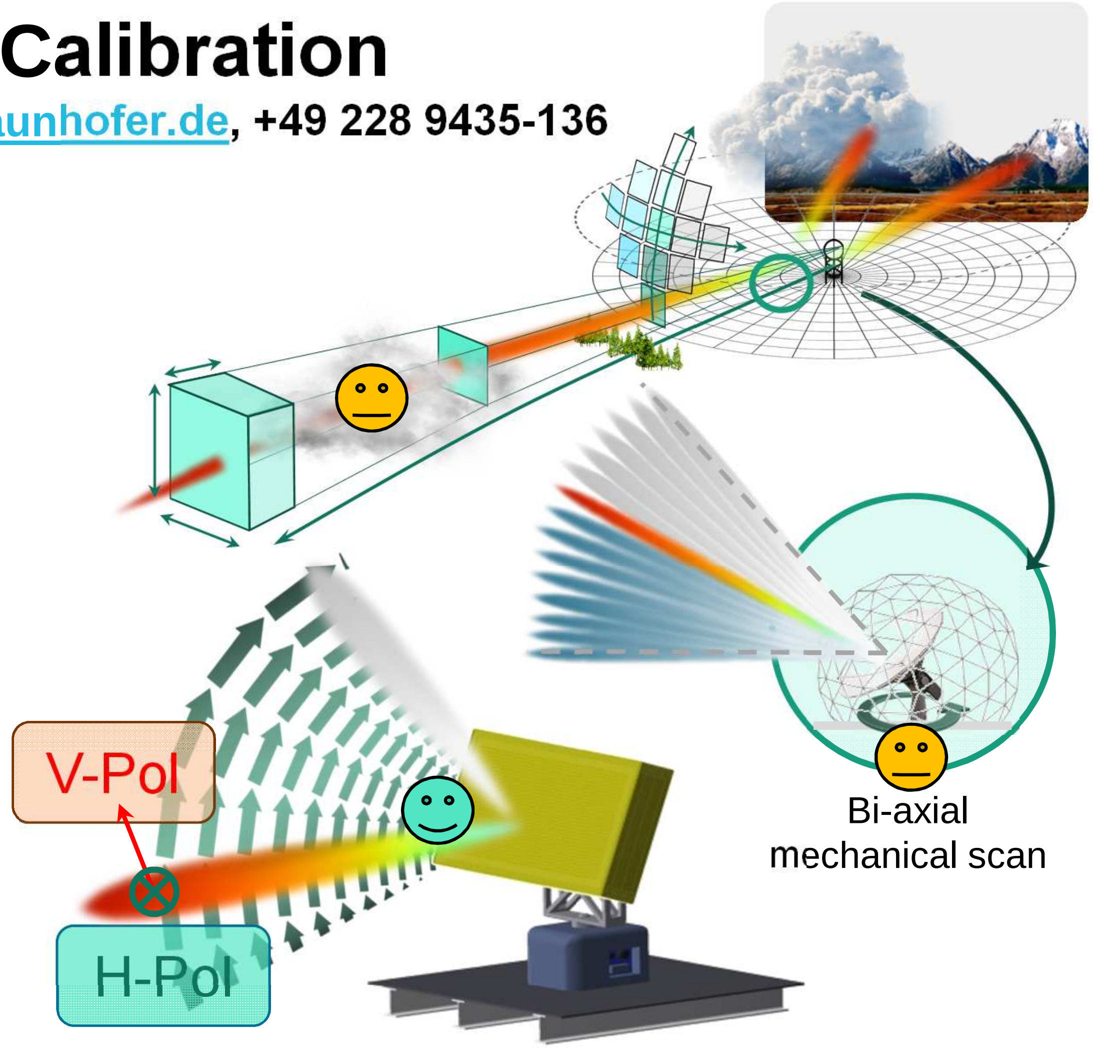
- Coarse update time (~5 minutes)
- Coarse spatial resolution at far range
- Beam blockage and extinction
- High cost (~M€)

Advancing to the next generation of weather radars requires

- Dense radar networks -> X-band, low unitary cost
- Dual-polarization and Doppler capabilities

Array calibration is fundamental to achieve the expected performance on real implementation

- Review and design of suitable techniques
- Measurements in anechoic chamber and on-field against known targets
- Process automization

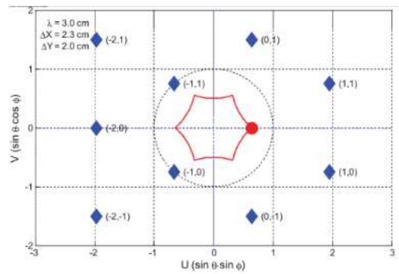


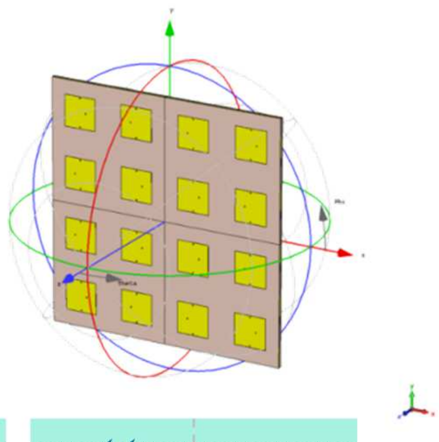
AESA Weather Radar. Sub-array lattice configurations.

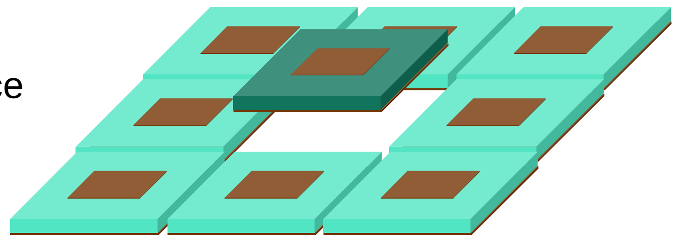
Contact: Dr. Stefano Turso, stefano.turso@fhr.fraunhofer.de, +49 228 9435-136

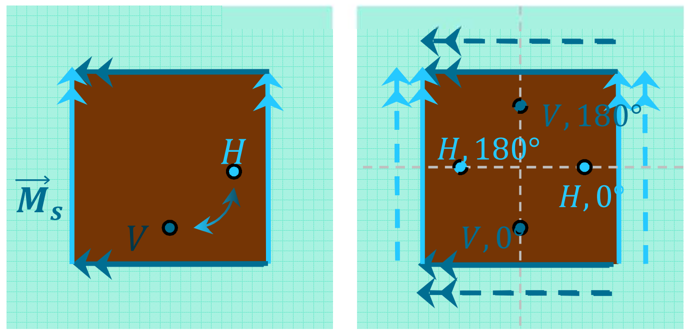
Based on a dual-polarized X-band patch antenna sub-array with low cross-polarization

- ***Investigate*** multiple lattice arrangements (squared, rectangular, triangular)
- ***Evaluate*** unconventional options like thinned arrays with good sidelobe control
- ***Develop*** design strategies and tools (Matlab)
- ***Simulate*** on industrial tools like CST Microwave Studio and ANSYS HFSS
- ***Select*** your optimal solution and propose it for manufacturing
- ***Measure*** the final performance (VNA, anechoic chamber)









Cross-polarization discrimination goal, **>30 dB**!

AESA Weather Radar. Signal and Data Processing.

Contact: Dr. Stefano Turso, stefano.turso@fhr.fraunhofer.de, +49 228 9435-136

Implement real-time demanding signal processing routines…

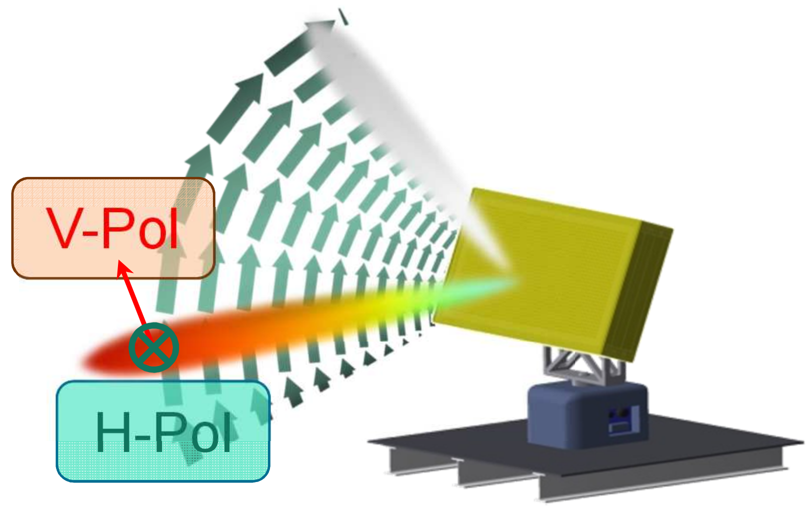
- Dual-linear polarization (ATAR mode)
- Pulse-Doppler FFT and Pulse-Pair Processing

…and complement with data processing.

- Evaluation of radar reflectivity
- and polarimetric moments

Use state-of-the-art tools and methodologies

- Algorithm implementation on a distributed architecture: FPGA, fabric cores, embedded PC
- Xilinx Zynq approach
- Signal integrity. Simulations and Lab measurements
- Performance benchmarking



“3D-Printed” Dielectric Resonator Arrays

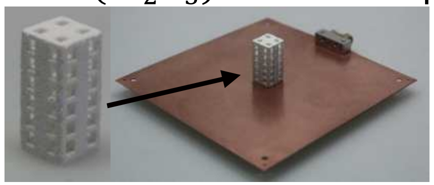
Contact: Andrej Konforta, andrej.konforta@fhr.fraunhofer.de, +49 228 9435-79025

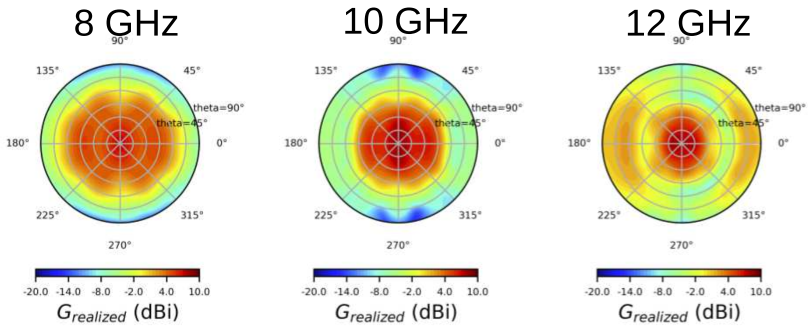
Theoretical Investigations
- Eigenmodes (basic radiator)
- radiation properties
- bandwidth limits

Modeling (HFSS)
- complex radiators
  - bandwidth enhancement
  - pattern stability
- feeding networks
- arrays

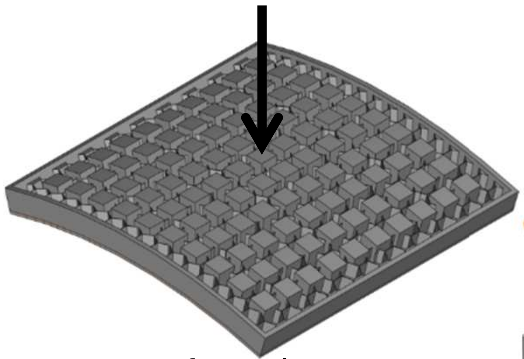
Materials
- resin based compounds (+ dielectric powder)
- Ceramics
- measurements (ε, μ)

Printed (Binder-Jetting) UWB(Al_2O_3) DRA with taper

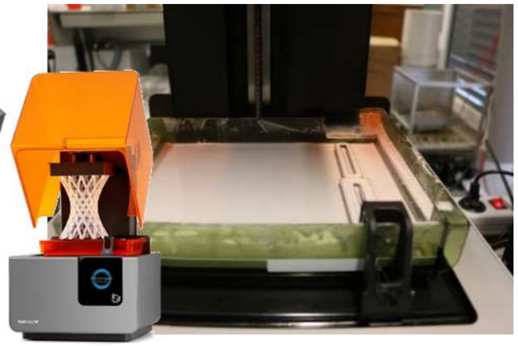


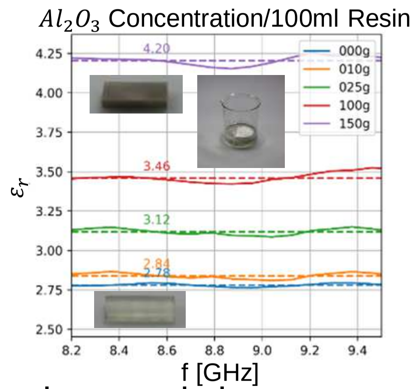


Simulated Far Field Pattern



Conformal 10x10 array (concept)





Improvement of COTS resin characteristics (stereolithographic printing process)

TU Delft Contact person: Prof. Alexander Yarovoy (A.Yarovoy@tudelft.nl)

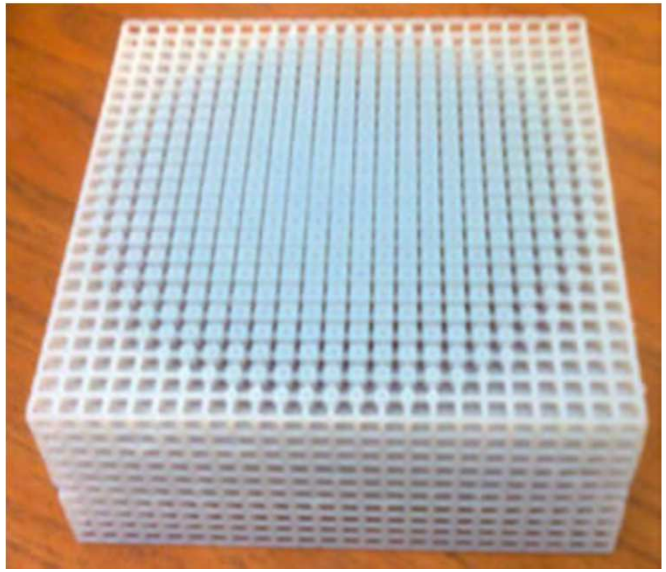
3DHF - Additive Manufacturing Processes in High Frequency Technology

Contact: Prof. Dr. Peter Knott, peter.knott@fhr.fraunhofer.de, +49 228 9435-176

Investigation of the potential of additive manufacturing processes for applications in high-frequency technology and the capabilities of current / expected future systems:

- What are the capabilities of the equipment and service providers available today in the industrial and research sector?
- Which materials and material combinations can be processed and what are their electromagnetic properties in the relevant frequency ranges?
- How can electrically conductive materials and insulators be combined, especially in the HF range?
- Which applications in the field of high-frequency technology have been investigated or are conceivable in the future?

Following the internship / student research project with a planned duration of approx. 3 months, a bachelor or master thesis in this field may be possible.



Application Example: Polymer-based 3D Luneburg Lens Antenna (Univ. Arizona)

TU Delft Contact person: Prof. Alexander Yarovoy (A.Yarovoy@tudelft.nl)

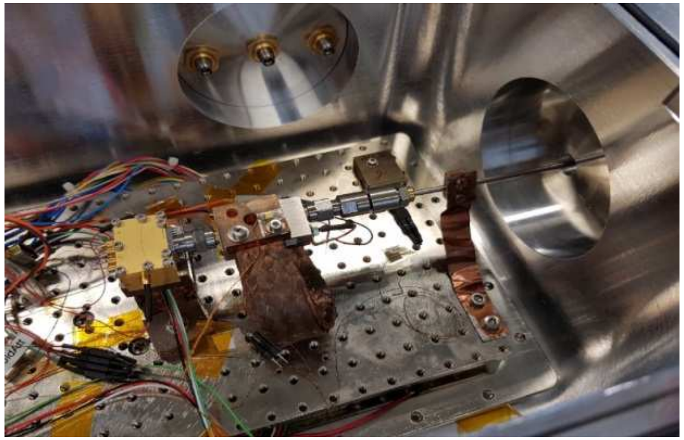
Measurement of Low-Temperature Material Parameter Variation

Contact: Prof. Dr. Peter Knott, peter.knott@fhr.fraunhofer.de, +49 228 9435-176

Evaluation of new concepts for the measurement of material parameters in actively cooled RF systems:

- Survey and literature review for measurement techniques with respect to the present application,
- Investigation of suitable (possibly new) concepts,
- Evaluation of performance (in simulations),
- Assembly / fabrication of a test device and experimental verification,
- Characterization of various materials,
- Documentation of results

The time frame and weekly schedule of the work can be set up depending on the student's requirements, both internship and thesis work is possible.



Test equipment with RF device samples in cooling environment.

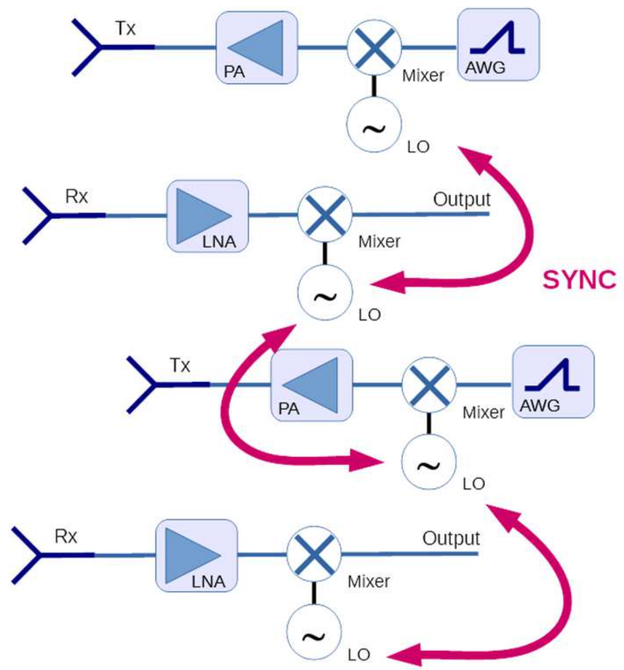
Synchronisation of Microwave Subsystems for Coherent Operation

Contact: Prof. Dr. Peter Knott, peter.knott@fhr.fraunhofer.de, +49 228 9435-176

Evaluation of new concepts for wireless synchronization of remote system and local oscillators for coherent operation in transmit and receive case:

- Review of the State-of-the-Art in Literature with respect to precision and ease-of-use
- Investigation of new concepts
- Evaluation of Performance (Simulation)
- Experimental Verification (if possible)
- Documentation

After an internship of approx. 3 Month, the formulation of a Bachelor- or Master Thesis Topic in this field of research could be feasible.



Synchronisation between multiple remote Transmit (Tx) and Receive (Rx) stations. For coherent operation where signals are combined in the far-field or receiver output with correct phase angles, a synchronisation reference signal must be distributed between Local Oscillators (LO).

TU Delft Contact person: Prof. Alexander Yarovoy (A.Yarovoy@tudelft.nl)

Fraunhofer FHR

Internship / student assistant (m/f) radar signal processing for space surveillance

Contact: Dr. Robert Kohlleppel, +49 228 9435-392

This position involves the development, analysis, implementation and testing of radar signal processing algorithms for space surveillance. You are going to work with a group of scientists.

What we expect from you:

- Above average grades in your studies in electrical engineering, mathematics, computer science or physics
- Ideally a specialization in signal processing, image processing, communications engineering or sensor data fusion
- Knowledge of a programming language (ideally MATLAB)
- Excellent skills in English
- Ability to work autonomously and in teams

What you can expect from us:

- A modern working environment
- Flexi-time and other attractive conditions of employment
- Good supervision

Further information: https://recruiting.fraunhofer.de/Vacancies/42100/Description/2

TU Delft Contact person: Prof. Alexander Yarovoy (A.Yarovoy@tudelft.nl)

Various Topics

Contact: Prof. Dr. Peter Knott, peter.knott@fhr.fraunhofer.de, +49 228 9435-176

Internships / Bachelor Thesis Topics / Master Thesis Topics:

- Doppler Analysis and Tracking Methods for 3D Radar Imaging
- 3D SAR and Rotating Scanner for Non-Destructive Material Testing
- Performance Analysis of HF Sky Wave Radar located in Germany (using existing evaluation software)
- Principal component analysis (PCA) based study of propagation data (using existing radar and weather data)
- Artificial Intelligent waveform design for specific radar modes
- Evaluation of the Utility of Forward Scatter Radar for Air Defence
- System Design and Analysis of a Multi-functional / Hybrid Sensor for Air Surveillance (radar-comms co-design)
- Can Pulsar signals be used to synchronize spatially-distributed radar nodes? Can Radio-Star (Pulsar) signals be received on small-aperture antennas and Software Defined Radio devices?

TU Delft Contact person: Prof. Alexander Yarovoy (A.Yarovoy@tudelft.nl)

1. Antenna diffuser “lens” to widen the antenna beam of an existing RF front-end

In some of our lighting applications, the mounting height of a 24GHz microwave RADAR sensor’s antenna can vary between 4m and 14m.
A narrow beam antenna is needed to achieve sufficient signal strength at 14m, while a wider beam antenna would be needed to have sufficient detection radius at a height of 4m.
Ideally only one patch antenna design is used to cover the full height range.
The assignment is to design and build an exchangeable lens/radome that acts as an “beam-widener” and can therefore be mounted for the lower heights.

2. Implement a neural network to optimize CW Doppler detection algorithm

At signify we have a limited data base which is used to train a neural network that is used for motion sensing (CW Doppler RADAR microwave).
Your challenge is to develop your own neural network (e.g. using keras/tensorflow) and develop a training method given the data.
A requirement for the algorithm is that its implementation in the C-programming language should fit a low level micro-processor (M0) that does not have a floating point unit.
Besides developing algorithms, you may like to gather more data yourself by carrying out some simple experiments.
Moreover, you are invited to develop new experiments which can improve the training of the neural network.

3. Signal signature characterization using machine learning on CW Doppler sensors

In commercial lighting applications preferably low cost, small physical size, single channel microwave sensors are used.
These operate at 5.8GHz in continuous wave Doppler mode and therefore have limited capabilities with respect to characterizing signal signatures (e.g. distinguishing between a walking person and a conveyor belt).
The assignment is to use machine learning to enable some kind of signal recognition (dataset will be provided and can be extended on request).

4. Interference mitigation of low cost 5.8GHz CW Doppler sensors

In commercial lighting applications preferably low cost, small physical size, single channel microwave sensors are used.
These operate in continuous wave Doppler mode and therefore are prone to disturbances (e.g. mechanical vibrations or EMI).
The assignment is to build a neural network to optimize the detection algorithm for motion sensing (dataset will be provided and can be extended on request).

Technolution B.V.
Burg. Jamessingel 1
P.O. Box 2013
2800 BD GOUDA
The Netherlands

T +31(0)182 59 40 00
E info@technolution.eu
I www.technolution.eu

MASTER THESIS PROJECT

Simulation of radar interference using the Technolution Traffic Simulator
Keywords: Radar, Traffic simulation, Ray Tracing, Software development

Technolution is developing a flexible road traffic simulator. This simulator supports a wide array of applications.

In order to improve the use of radar for inter-vehicle communication, real-world models are required. In this master thesis project, the traffic simulator will be extended with a model for calculating the cumulative radar interference resulting from radar sources present in a realistic traffic scenario.

The scene description contains a 2D representation of vehicles and buildings. Using a ray-tracing algorithm, a first order approximation of the radar area can be determined. In a more advanced setup, the vehicles are moving according to the traffic simulation. This results in statistics for the number of vehicles seen over the course of time.

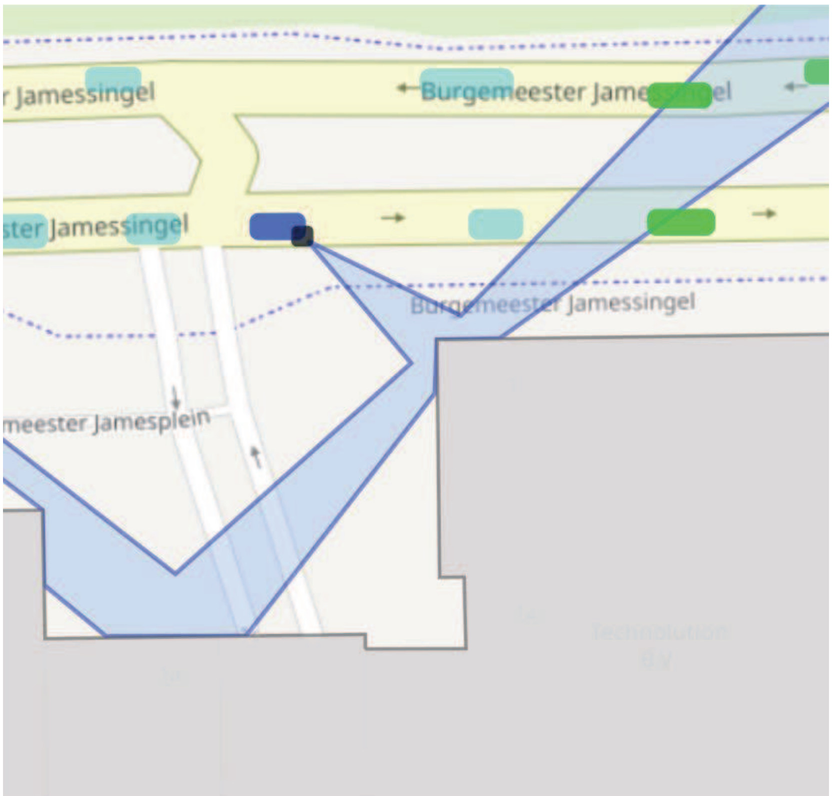


Figure: Radar interference is determined for the blue vehicle.

Contact: Tijs van Bakel, tijs.van.bakel@technolution.nl

Airborne bistatic RADAR signal antenna design

Context
In collaboration with Selfly BV the TU D is involved in the development of radar based avionics systems, which eventually will allow aircraft to fly in low visibility conditions. By detecting and processing radar signals the aircraft should be able to determine and track the location of obstacles (both airborne and on the ground) giving the aircraft enough information to navigate as well as detect other aircraft.

Currently we are performing test flights with a Socata TB-10 (see picture) to gather raw data on the performance of prototype systems. A future system will also be based on a bistatic principle using primary radars of Air Traffic Control centres as illuminators. This will be the focus of your assignment.

SOCATA TB-10 with radar antenna

MSc Assignment
The challenge is to develop an antenna setup to optimally detect primary radar returns as well as have directional capability. You will also have to design the antenna setup to be airworthy leading to extra requirements on size, weight and strength. The signals will be fed into a multi channel SDR system. Typically, ATC primary radars use the following parameters:

frequency: 2 700 … 2 900 MHz
pulse repetition frequency (PRF): 10000 pps (short pulse)
850 to 1150 pps (long pulse)
pulsewidth (τ): 1 µsec and 75 µsec
instrumented range: 60 or 80 NM
range resolution: 700 ft
beamwidth: 2.3 degrees
antenna rotation: 4 s (15 rpm) or 5s (12 rpm)

your antenna design will be tested both in ground trials as well as airborne flight tests.

For more information contact:

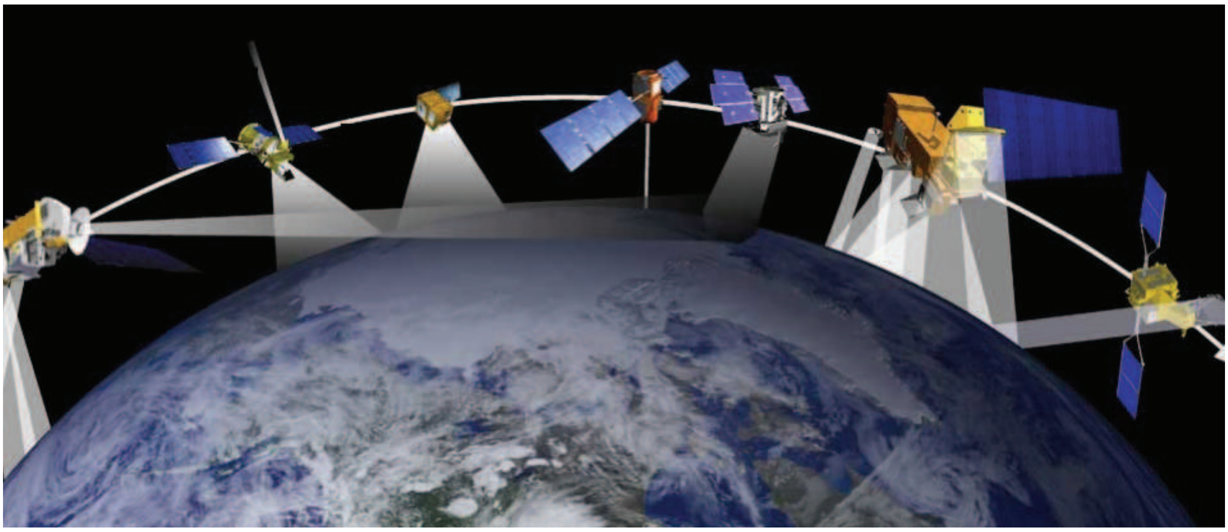
Ir. R.N.H.W. van Gent rvgent@selfly.nl

TU Delft

Joint Optimization of Baseline and Pulse Repetition Rate for Small Spaceborne Radar Network for an Earth Observation Systems.

The project is framed within the Dutch network on small spaceborne radar instruments and applications (NL-RIA) and aims at deriving new Earth Observation mission concepts based on SmallSat platforms.

This master thesis project will particularly concentrate of the design of a small spaceborne radar network. The pulse repetition frequency (PRF) is a sensitive design parameter in the spaceborne SAR systems. A low PRF value is necessary to obtain high swath width while a high PRF value is required for high azimuth resolution, in order to process high azimuth bandwidth echoes. The displaced phase center (DPC) technique allows oversampling of the echoes in azimuth direction by using the distance (baseline) between multiple satellites since each satellite samples the echoes in reference to a different Doppler centroid. This allows the use of a lower physical PRF value of the transmitted signal without any aliasing problems.



Assignment

The proposed project has the goal to develop and implement methods for onboard processing strategies for SmallSat network platforms. The list underneath provides an overview of the research questions that will to be solved in this project:

- Joint optimization of baseline and PRF for small spaceborne radar network
- Design and implementation of a real-time SAR imaging techniques for the proposed system.

Requirements

MATLAB, Python, Radar basics

Contact: dr. Faruk Uysal,

Microwave Sensing, Signals and Systems

f.uysal@tudelft.nl

radar.tudelft.nl

Research Theme
Next Generation Sensing & Communication

A Fully Flexible Single-Side-Band Radar Deramping Receiver on FPGA

At the present time, there are different radars for different sensing goals. These radars have different architectures and unique processing chains. This has undesired implications, such as financial and power consumption. Current radars - in academia - can switch between a library of waveforms (WF1: search, WF2: track, etc.), or are hard-coded for specific purposes. It is therefore desired that switching between configurations happen in a more continuous manner for different applications. Receiver-chain blocks need to facilitate and allow their own adaptability, by being reconfigurable on request from a radar-management block. The management-block will also have to dictate the waveforms in use, and their supplementary signal processing, in association with a desired sensing goal.

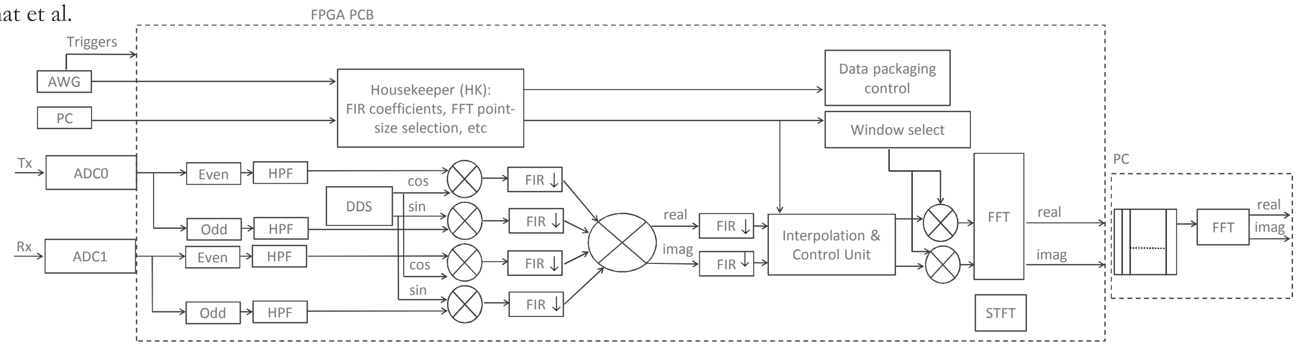
This work focuses on the FMCW class of radars and their waveforms, where the project addresses:

- Receiver-chain parameters, tradeoffs, design and implementation considerations.
- Implementation and testing on FPGA boards.

Adaptive Receiver Requirements

- Online FIR filtercoefficients reload. (already built, only needs to be integrated)..
- Implement Short-Time Fourier Transform (STFT) on the FPGA using Xilinx blocks in Simulink
- FFT point-size online select.
- Window selection automation. Can be stored on chip/off-chip or calculated online.
- Xilinx Direct Digital Synthesizer (DDS) centre frequency online reconfigure.
- Two-way switchers between PC and FPGA using Digital I/O (DIO).
- Arbitrary Waveform Generator (AWG) to control a few DIOs to indicate a certain functionality/command etc, like a switch of waveform for example. (implementation examples available in the AWG documentation).
- Use existing Innovative Integration (II) blocks to allow read/write data from on-board (off-chip) memory(s).
- Complete change of receiver architecture based on request from PC or AWG via Xilinx partial dynamic reconfiguration (PDR). An example would be to switch from a single-sideband to a double-side-band receiver.
- Use existing II blocks and protocol for data exchange between FPGA boards (networking capability).

Note: These requirements are directly linked to a few radar system level requirements. For example changing the Pulse Repetition Frequency (PRF). This is discussed in the paper "Waveform and Receiver Parameters Design Choices for a Reconfigurable Digital FMCW Radar" by S. Neemat et al.

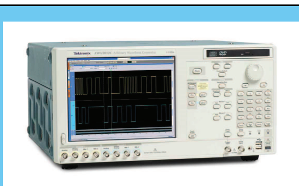


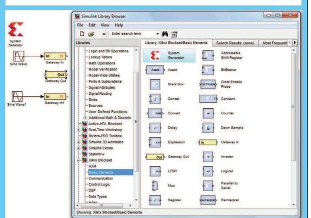
Board & Development Environment

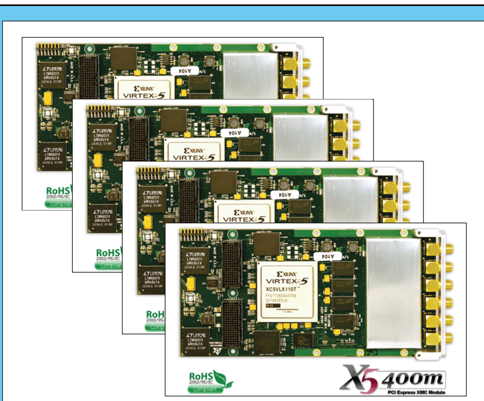
Board:
Innovative Integration (II)
X5-400M.
Development Platforms:
Simulink (Xilinx system generator),
Xilinx ISE.

MATLAB SIMULINK

XILINX ISE DESIGN SUITE







Delft University of Technology, EEMCS, MS3 group, The Netherlands
For more information contact:
S. Neemat (S.A.M.Neemat@tudelft.nl)
O. Krasnov (.a.krasnov@tudelft.nl)
A. Yarovoy (A.Yarovoy@tudelft.nl)

TU Delft
Delft University of Technology

Investigating the convergence of algorithms for Radar Sensor Management

Due to improvements in hardware and software, radar systems are getting more and more degrees of freedom. Some examples are the rise of phased-array antennas, digital beamforming (DBF) and digital waveform generation. This led to so-called multi-function radar (MFR) systems. In the past, a radar was usually only used in a single mode and multiple radar tasks often needed to be performed successively or by separate radar systems. Nowadays, MFRs are able to execute many functions jointly and practically in parallel, especially due to the possibility of very quick changes in the direction of the beam by the use of phased-array antennas.

The biggest problem is that the resources of a radar system, especially the sensor time, are limited. Therefore it is common for a radar to work in some kind of overload situation where it cannot give all objects the same amount of attention. Due to the fact that MFRs are supposed to handle many different tasks in parallel, those limited resources have to be distributed to the different tasks according to their importance. This means that more important tasks will receive a higher amount of sensor resources than less important ones. Subsequently, a schedule of the different tasks has to be made according to the assigned resources. The main challenge in Radar Sensor Management (RSM) is to make a decision about the task importance, or in other words the cost of not spending any resources on it. Therefore, a solution of this problem consists of an algorithm that decides on a distribution of the radar resources by minimizing those costs and ultimately a schedule of when to perform those tasks. In order to do this, also the constraints of the system have to be taken into account, like the available sensor time for instance.

Our approach consists of using a combination of a constrained Partially Observable Markov Decision Process (POMDP) and Lagrangian relaxation. The POMDP framework will be used to implement a non-myopic RSM, which means that future time steps are going to be taken into account for the next best action to take. By applying Lagrangian relaxation, the optimization problem can be simplified by including the constraints into the objective function and decoupling the overall problem into smaller optimization problems, one per task.

In order to find an optimal solution with Lagrangian relaxation, algorithms need to be used that recursively find the optimum for the Lagrange multipliers. Some possible algorithms are the subgradient method, the Nesterov accelerated gradient descent or the proximal algorithm.

The project will consist of several parts:

- Understand the background of RSM and study some possible approaches [1][2][3].
- Study certain aspects of convex optimization theory and Lagrangian relaxation [4][5].
- Review different iterative methods to solve constrained convex optimization problems [6][7].
- Apply the found methods on Lagrangian relaxation in a typical RSM framework (for instance assigning sensor time to different targets in a tracking scenario).
- Investigate the influences of different input values for the algorithms (for example the initial guess or the step size) and how multiple algorithms can be combined for improved performance.

Contact: Max Ian Schöpe (m.i.schope@tudelft.nl)

References:

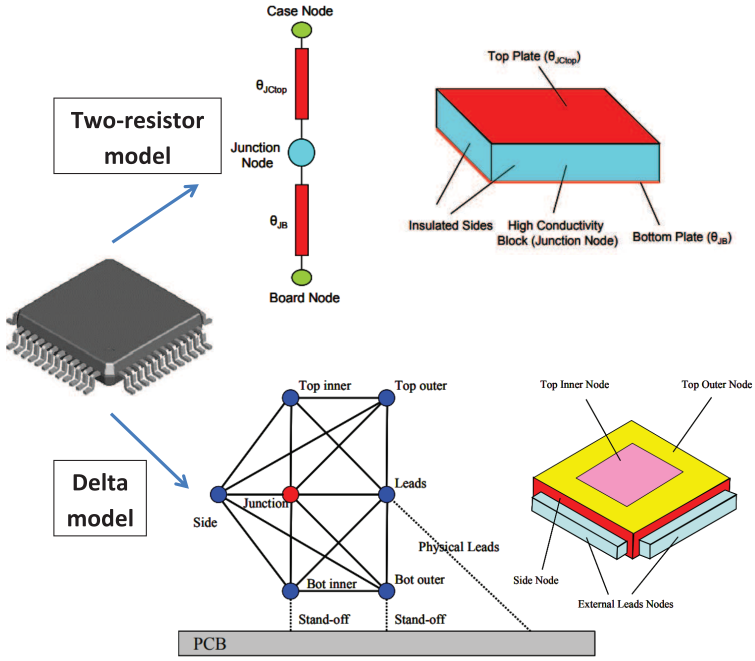
[1] P. W. Moo and Z. Ding, Adaptive Radar Resource Management. Academic Press, 2015.
[2] A. O. Hero and D. Cochran, "Sensor Management: Past, Present, and Future," IEEE Sensors Journal, vol. 11, pp. 3064-3075, Dec 2011.
[3] A. O. Hero, D. A. Castan, D. Cochran, and K. Kastella, Foundations and Applications of Sensor Management. Springer Publishing Company, Incorporated, 1st ed.,2008.
[4] S. Boyd and L. Vandenberghe, Convex Optimization. Cambridge University Press, 1st ed., 2004.
[5] D. Bertsekas, Convex Optimization Theory. Athena Scientic, 1st ed., 2009.
[6] Bertsekas, Dimitri P. (2015). Convex Optimization Algorithms. Belmont, MA.: Athena Scientific. ISBN 978-1-886529-28-1.
[7] Sébastien Bubeck (2015), "Convex Optimization: Algorithms and Complexity", Foundations and Trends in Machine Learning: Vol. 8: No. 3-4, pp 231-357. http://dx.doi.org/10.1561/2200000050

Thermal Simulations for 5G Integrated Antenna Arrays

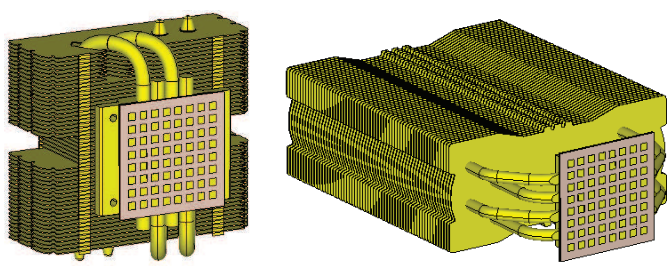
- Managing the large amount of heat dissipated by the 5G mm-wave transceiver chips is a challenging task.
- For reliable and safe operation at the 5G base stations, a complete simulation & design of the integrated antennas (radiators, chips, cooling modules etc.) is needed.
- Quantitative thermal analyses must be performed together with the electromagnetic simulations in order to decide on the cooling strategy and investigate the capabilities of the selected cooler.

Compact 5G antenna system designs in mm-waves require the use of highly dense transceiver chips that include DACs/ADCs, PAs, LNAs, PLLs, Tx/Rx switches, filters and so on. The power dissipated by all these components (mostly by the inefficient PAs) makes cooling a significant issue. Besides, the highly-packed front-end circuitry at mm-waves makes integration of cooling systems challenging. Furthermore, high-volume 5G market favors a fully-passive, easy to maintain and low-cost cooling solution to be employed at the base stations via the use of heat sinks, heat spreaders, heat pipes or thermal interface materials instead of fans or forced liquids that require the use of electricity.

The basic two-resistor model has recently been used to study the thermal management aspects of passively-cooled 5G base station antennas. However, an extended model with larger number of thermal resistances should be developed for more accurate and reliable simulation results.



Sample mm-wave 5G antenna arrays with an integrated cooling structure (CPU heatsink)



Research topics of interest include:

- Realistic thermal modeling of the chips
- Passive vs active cooling
- Conduction-focused vs CFD tools
- Parametric studies with various cooling modules / approaches

Aim of the Project

- Apply the Delta thermal model in simulation
- Study the conduction-focused and computational fluid dynamics (CFD) tools
- Investigate capabilities of different coolers / cooling strategies

Contact person: Yanki Aslan (Y.Aslan@tudelft.nl)

5G System Studies with Active Multi-Port Sub-Arrays

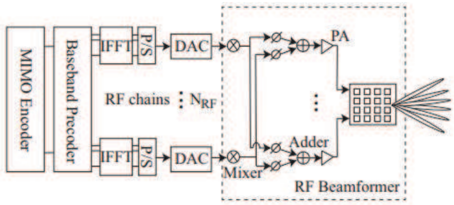
- In the first phase of 5G systems, it is important to design low-cost and low-complexity products with sufficiently high performance.
- To satisfy the demanding 5G criteria, novel array front-end architectures are needed.
- Statistical RF performance of the complete communication link should be investigated parametrically via Monte-Carlo simulations to estimate the average system performance.

In order to understand the feasibility of achieving the desired goals (the number of users that are simultaneously served, data rate per user, maximum distance for reliable communication etc.) with certain limitations (the size of the aperture, number of antenna elements, power amplifier capabilities etc.), it is important to model the behavior of 5G systems. Incorporating different array front-end architectures in the system model has recently gained remarkable attention with the growing interest in low-complexity & high-performance 5G systems.

In the 5G literature, two hybrid beamforming topologies are commonly seen: fully-connected and partially-connected.

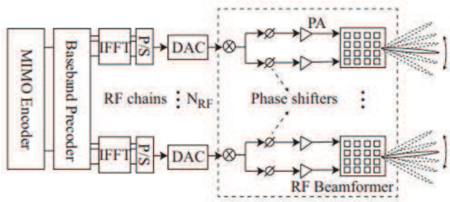
Active multi-port sub-array architecture is a promising alternative to the existing techniques due to its reduced processing complexity and functional flexibility.

Fully-connected architecture



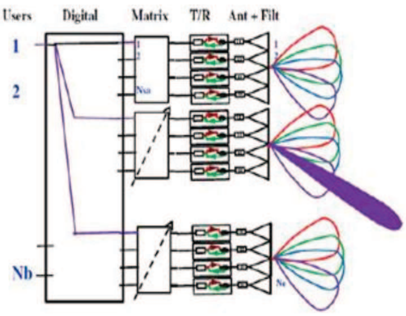
- Simultaneous multiple independently scanned beams
- Each beam has its own beamforming structure (analog or digital)
- Mixing of signals in PAs with combining losses
- Large number of phase shifters, adders

Partially-connected architecture



- 1 beam per user per single port array (classical MIMO)
- Relatively simple signals in PAs
- Less phase shifters, no adders

Active multi-port sub-array architecture



- Multiple beams at sub-arrays
- Matrix: RF, IF or digital
- Sub-array beams can be orthogonal, fixed via Butler matrix, Rotman lens etc.
- One weight per matrix instead of one weight per element (complexity is reduced by Nsa)

Research topics of interest include:

- 5G channel model & link budget
- Adaptive / user-specific beam selection & excitation strategies
- Statistical analysis of SINR and BER
- LoS vs NLoS propagation

Aim of the Project

- Study the system performance of active multi-port sub-arrays via Monte-Carlo simulations
- Investigate different simulation scenarios & use-cases with multi-port sub-arrays using different beamforming approaches

Contact person: Yanki Aslan (Y.Aslan@tudelft.nl)

Learning...

One of Europe's most renowned radar institutes Fraunhofer FHR cordially invites you to join us for our International Summer School on Radar / SAR.
We offer the unique opportunity to gain an in-depth education on radar and synthetic aperture radar (SAR) techniques by distinguished international lecturers.
Our programme covers a wide range from radar fundamentals to state-of-the-art Radar / SAR systems to sophisticated signal processing techniques and their applications.

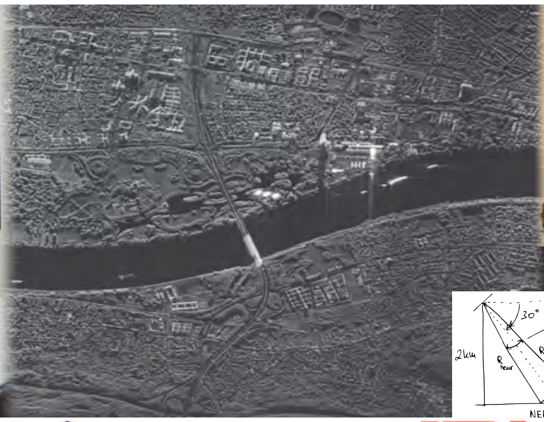
... and Enjoyment!

As a student of the Int. Summer School on Radar / SAR you are welcome to a stimulating academic environment in a vibrant atmosphere among international radar specialists and experts (approx. 40 students). Our intellectually rewarding courses and workshops, which will manifest the theory of the lectures, are accompanied by excursions as well as cultural and social events, introducing you to UNESCO's World Heritage, the Upper Middle Rhine Valley by a bicyle tour and to the vibrant city of Cologne.

More information on http://www.radarsummerschool.fraunhofer.de/

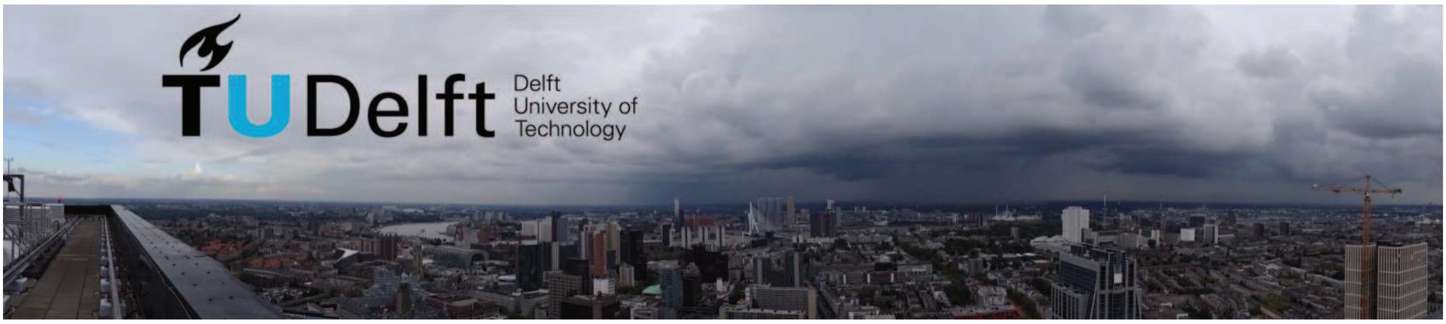
Relish learning

SAR image of the Rhine at Bonn



Workshop

IEEE
RWTH AACHEN UNIVERSITY
VDE
SAPIENZA UNIVERSITÀ DI ROMA
DRDC | RDDC
JPL
instituto de telecomunicações
Fraunhofer FHR



Microwave

Sensing, Signals and Systems (MS3) Group

INVITATION

MS3 MASTER EVENT

Come to learn about our group and current Master Thesis Projects

January 11th

Event Program

15:30 – 18:30

Start & Welcome
(Snijderszaal (HB 01.010)

Introduction of MS3

Short presentation of companies (NXP, TNO, THALES and RFx Solutions)

Free interaction for Master project opportunities

18:00 Social Time & Pizza