Non-terrestrial 6G activities at CWTe

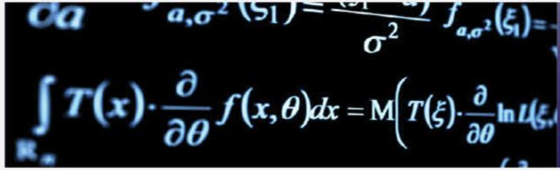
KIVI EVENT ON "SATELLITE COMMUNICATIONS FOR 5G AND BEYOND" AT SPACE EXPO NOORDWIJK

Dr. Ulf Johannsen, Director CWTe

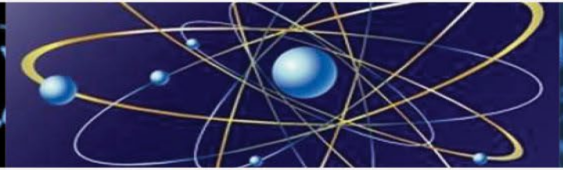
Centre for Wireless Technology (CWTe)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

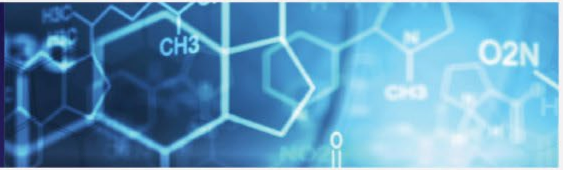
Nine departments



Mathematics & Computer Science

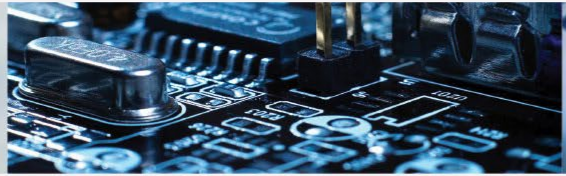


Applied Physics



Chemical Engineering

Mechanical Engineering



Electrical Engineering

Biomedical Engineering

Built Environment

Industrial Design

Industrial Eng. & Innovation Sciences

Department of Electrical Engineering

1200 BSc and MSc students

80 scientific staff members

>250 PhD students

Intense cooperation with High-tech industry and research institutes (e.g. Philips, NXP, ASML, DAF, VDL, TNO, ASTRON, Prodrive, …..)

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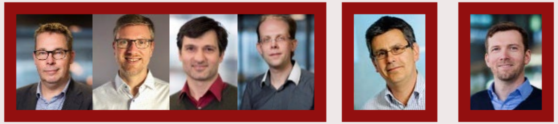
Center for Wireless Technology Eindhoven – CWTe

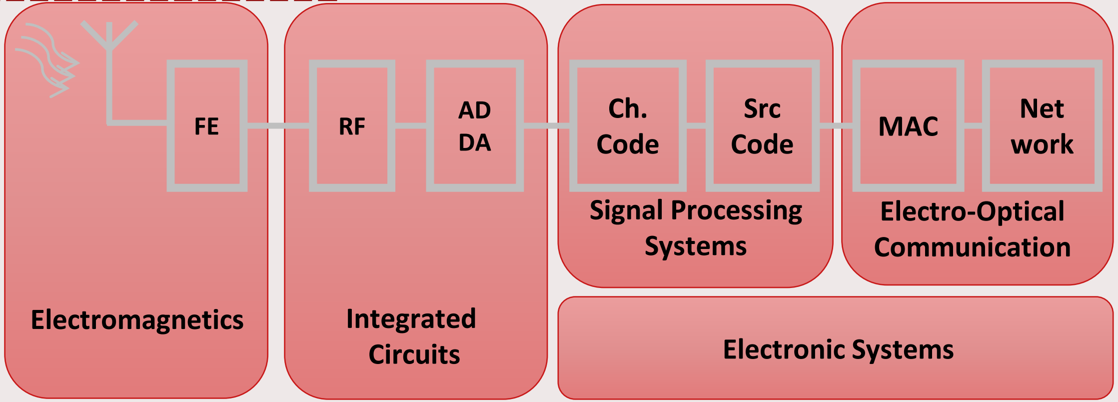


Program Board Chairs Bus. Dev. Director

MT

SPS

ECO



EM

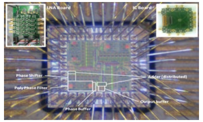
IC

ES

CWTe Research Programs

Ultra-high data rates (Chair: Dr. Sander Bronckers)

- High Frequencies (>= 26 GHz) and very high data rates (1Tbps)
- Smart antenna systems, phased arrays, optical wireless
- Next generation RAN (cell-free M-MIMO, non-terrestrial networks)

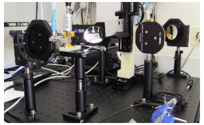


Ultra-dense ultra-scale AI-driven networks (Chair: Dr. George Exarchakos)

- Ultra small, ultra-low power and battery-less wireless systems
- Self-configuring networks, autonomous devices and AI
- High-reliability and ultra-low latency

Ranging and sensing (Chair: Dr. Dook van Mechelen)

- Accurate, cheap, low-energy, one-chip radar
- Sensing and positioning (3D, under water)
- All frequency bands



Radio Astronomy (Chair: Prof. Mark Bentum)

- Next generation radio telescopes
- Large antenna arrays
- Low frequency (<30 MHz)

EM **IC** **ES** **SPS** **ECO**

CWTe Labs

- Co-located and integrated laboratories, occupying about 700m^2
- Labs for all different sub-disciplines of wireless systems
- Dedicated system integration lab
- Fully shielded
- Anechoic chambers
- Reverberation chambers
- On-wafer, PCB-level and system-level characterization

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Contents

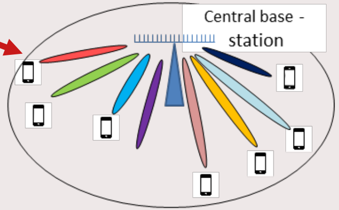
Telecommunications Heritage within CWTe

TU/e

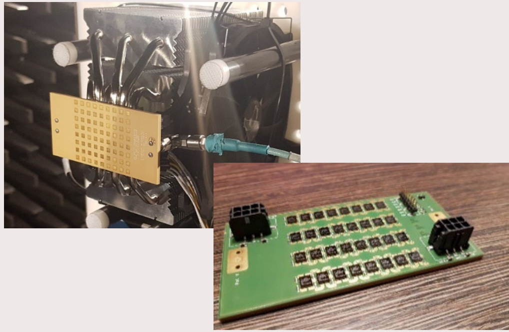
NXP

ERICSSON

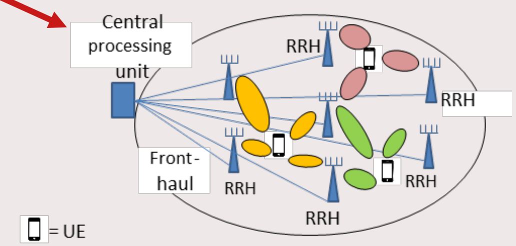
- 2016 – 2020: SILIKA
  www.silika-project.eu/



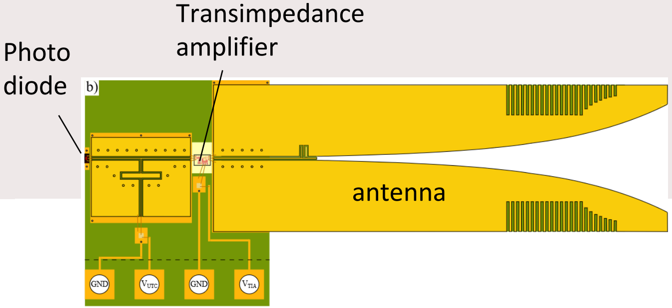
(a) Centralized



- 2019 – 2023: MYWAVE
  www.mywave-project.eu/



(b) Distributed



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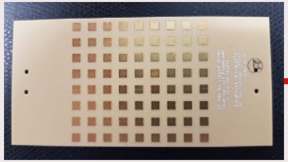
Key outcomes

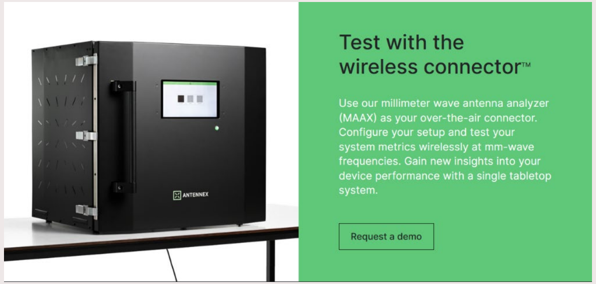
- 6G antenna front-end development of NXP + Ericsson + TU/e support:



28GHz → 100GHz

- TU/e spin-off:

ANTENNEX



- TSMC offers access to 16nm and 7nm process for large discount

tsmc

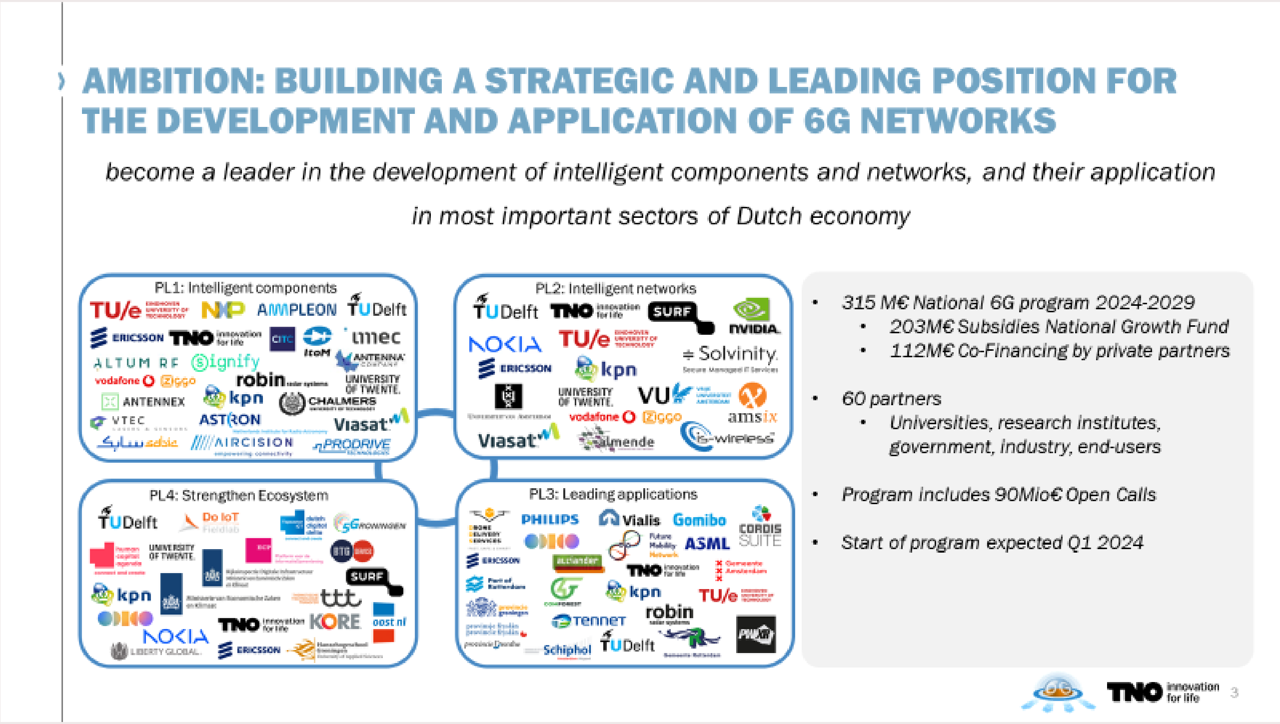
Current and Upcoming Activities

- 2022 – 2026:
- 2024 - 2030:

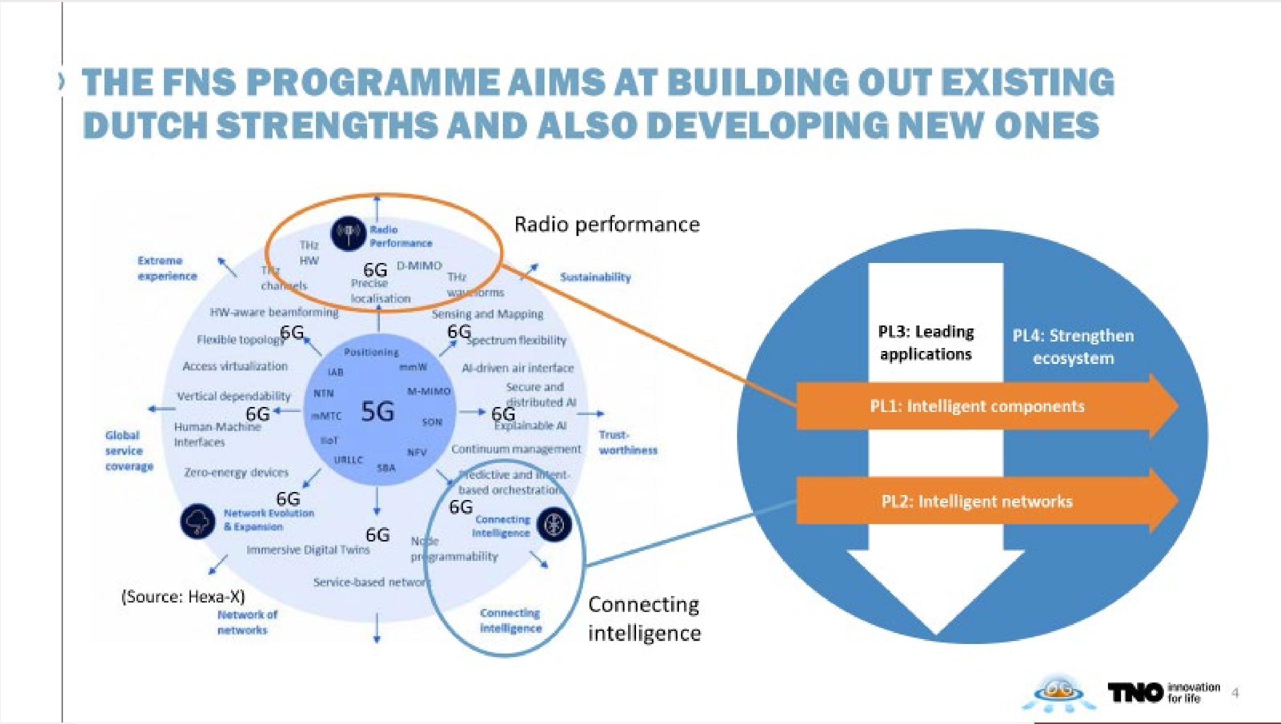
Contents

- History – Why CWTe is working on SatCom
- Groeifonds project 6G Future Network Services
- EU project ANTERRA
- First results

6G Future Network Services – National Growths Fund



6G Future Network Services – NL Strengths



TU/e asked to lead "Intelligent Components" work package

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6G SatCom: Potential 6G FNS partners

Vodafone
KPN
Ericsson
Nokia
Viasat
Antenna Company
NXP
Ampleon
Altum RF
TNO

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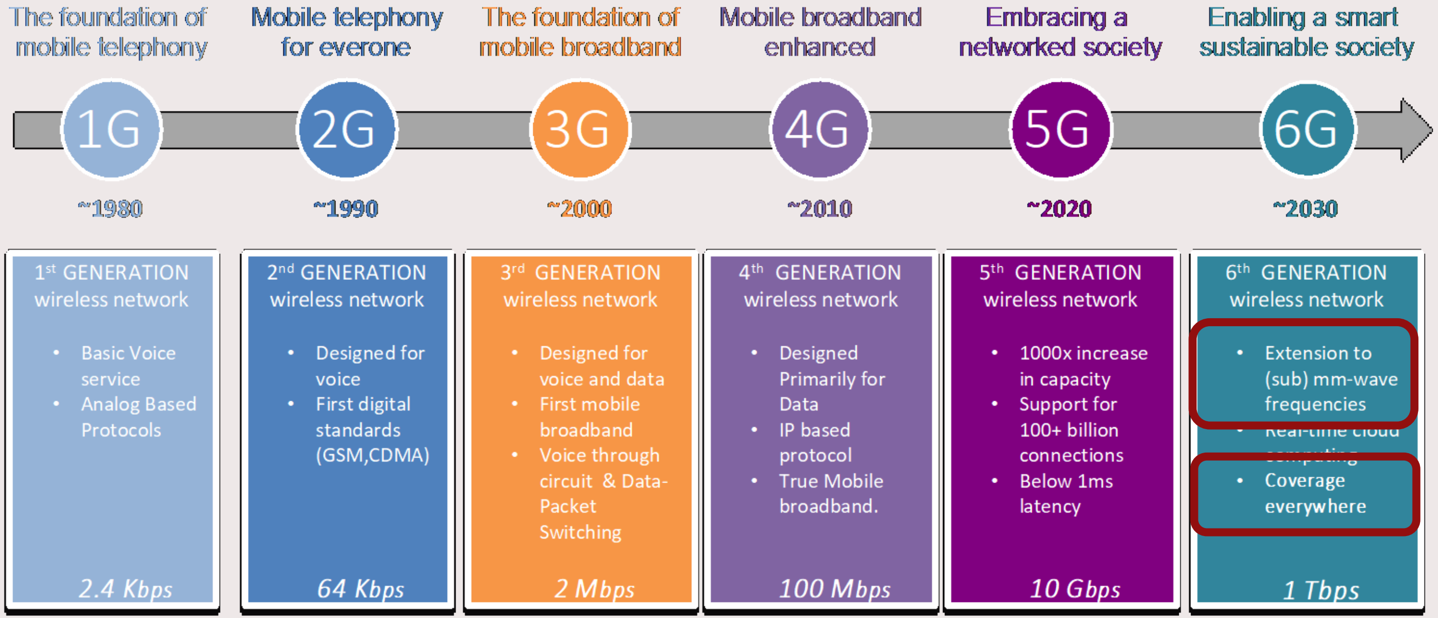
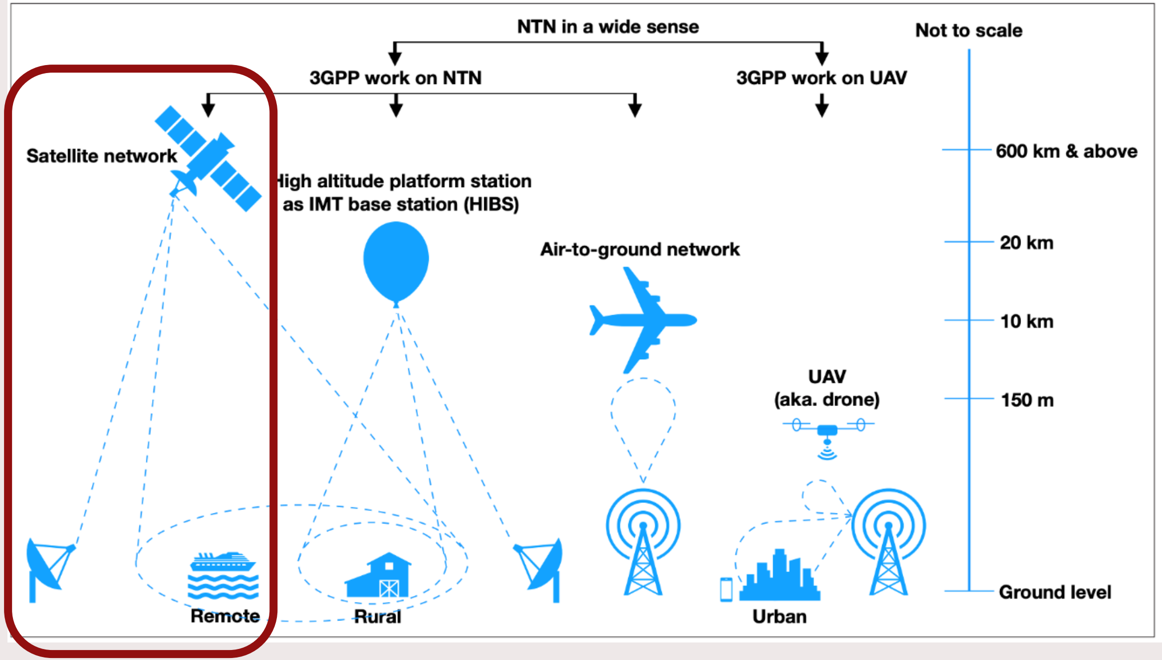
What is 6G? – Mobile Communications Timeline



Non-terrestrial Network Types



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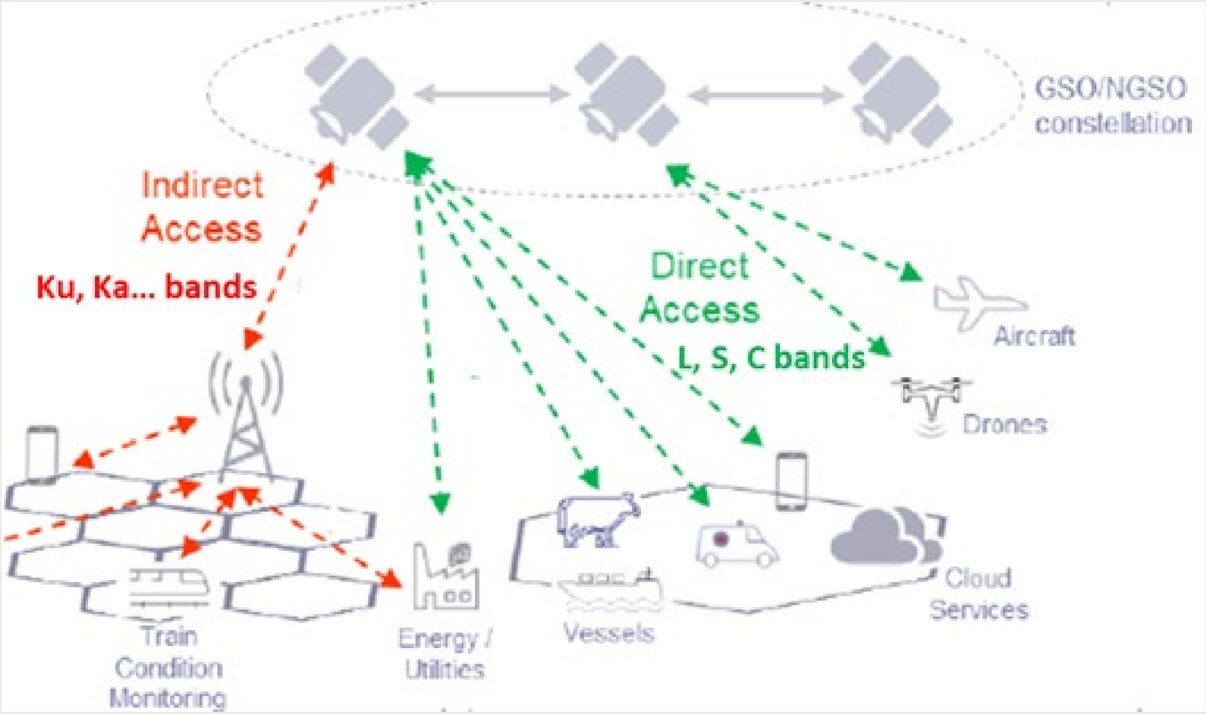
Role of Satellite Communication in 6G



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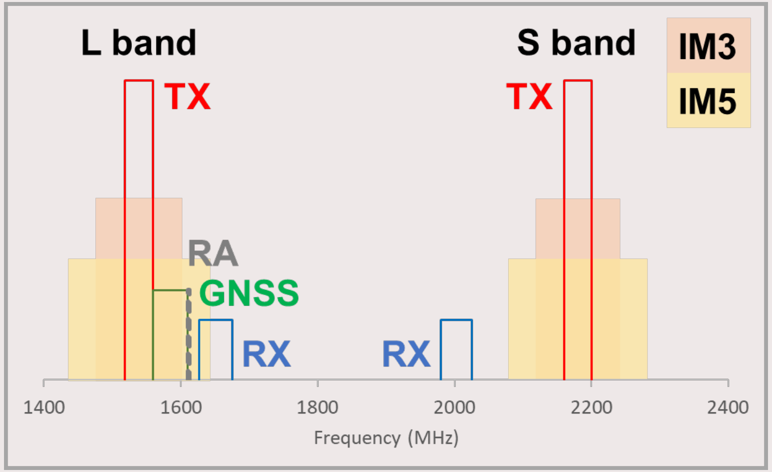
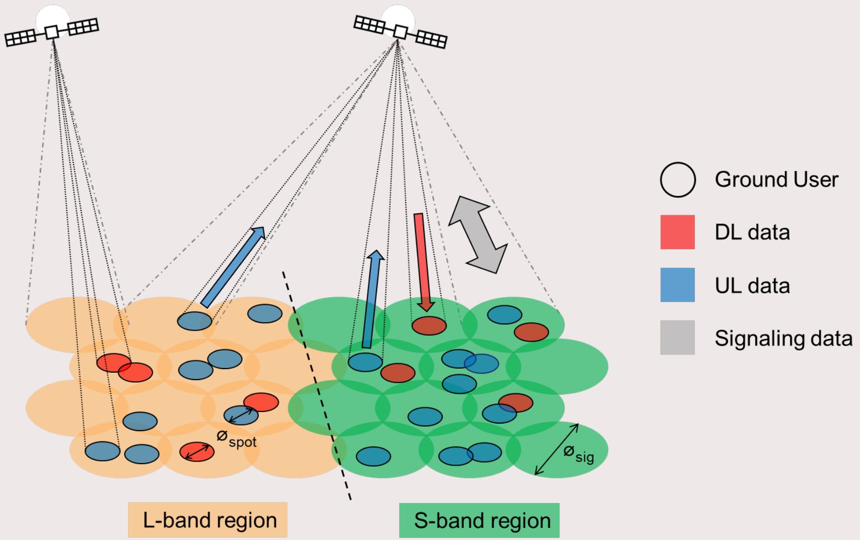
Direct 6G Connectivity to mobile phones

- Dual band: L+S-band depending on region
- Up to 10s of thousands of beams
- Circular polarization for alignment

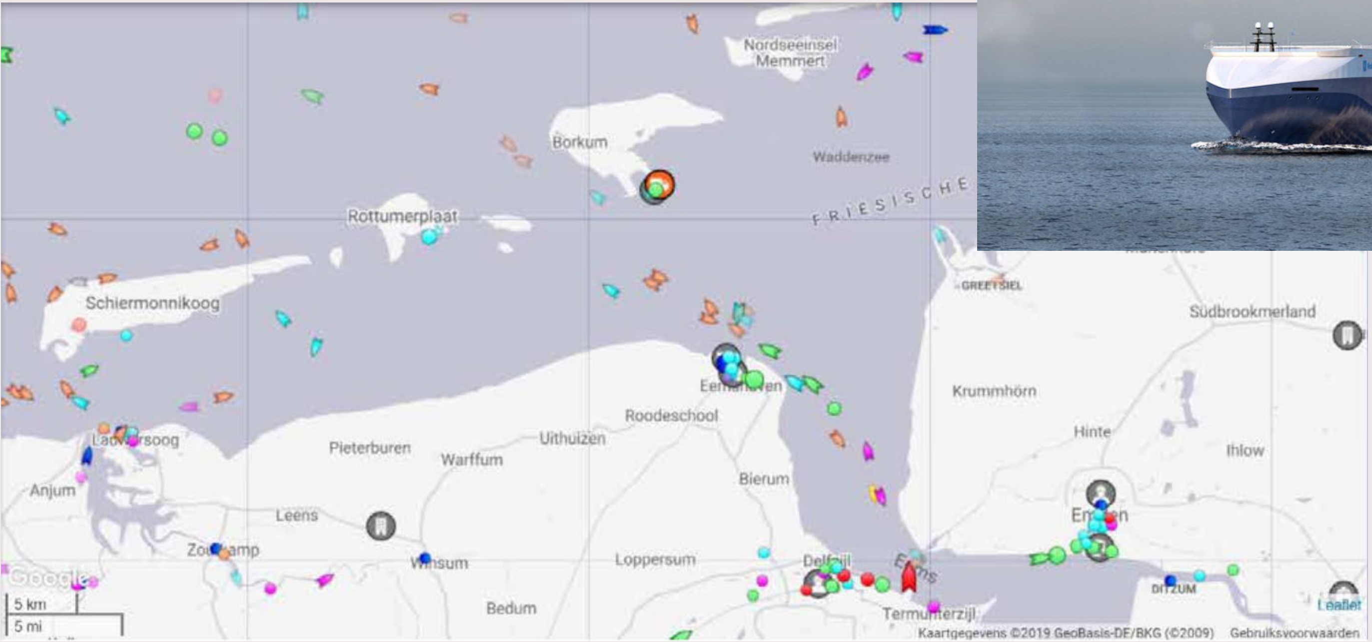




Main challenges:

- Array design: Low-profile, wide-band, wide-scanning, compact
- Tx-to-Rx self-interference
- GNSS / RA interference compliance

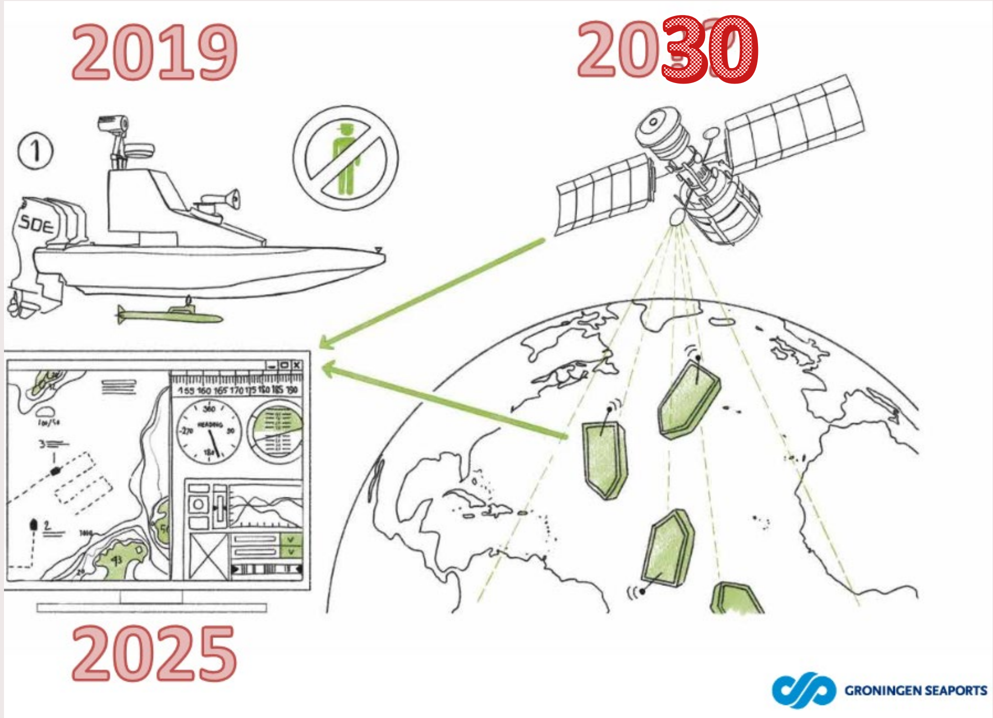
Example application: Autonomous shipping



Source: Henk Zwenksloot
CWTe Research Retreat 2019

GRONINGEN SEAPORTS CWTe CENTER FOR WIRELESS TECHNOLOGY EINDHOVEN TU/e

Example application: Autonomous shipping



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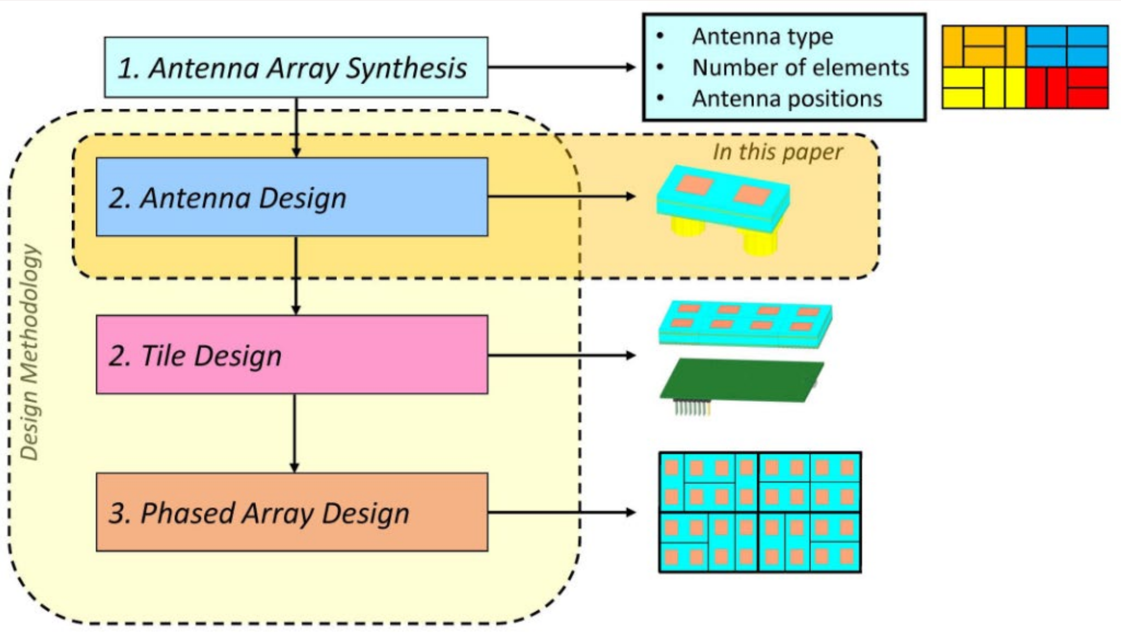
Customizable Phased Array Antenna based on Domino Tiles for Satcom Applications (1/8)



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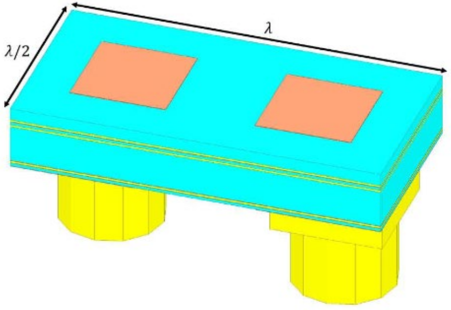
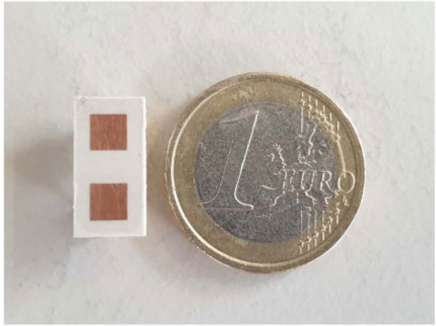
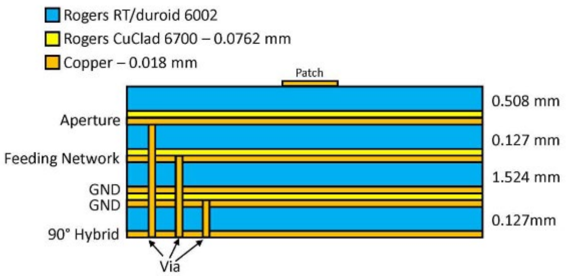
Customizable Phased Array Antenna based on Domino Tiles for Satcom Applications (2/8)



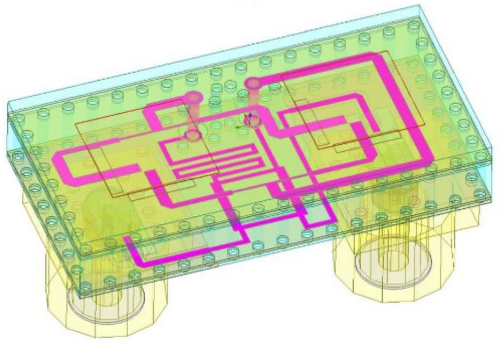
(a)



(b)

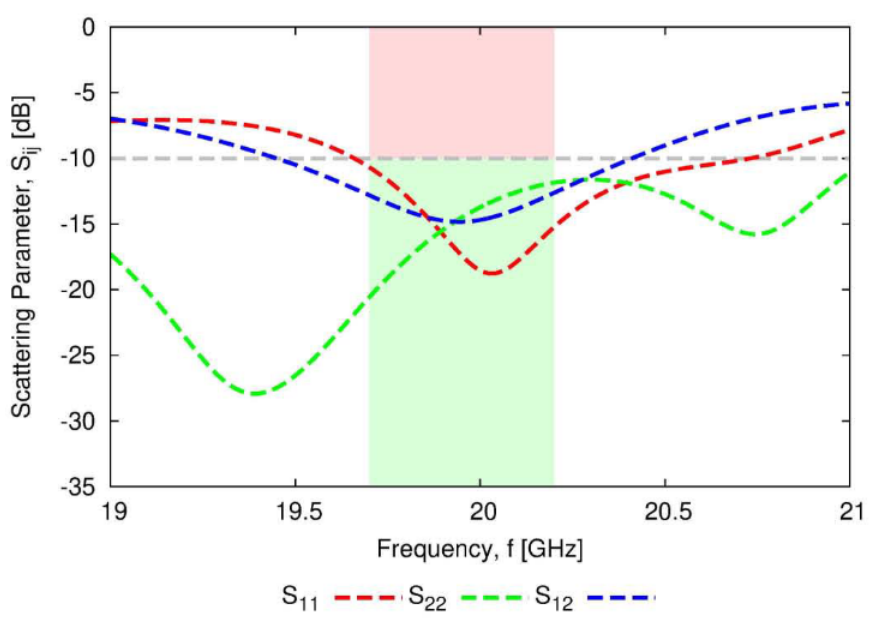


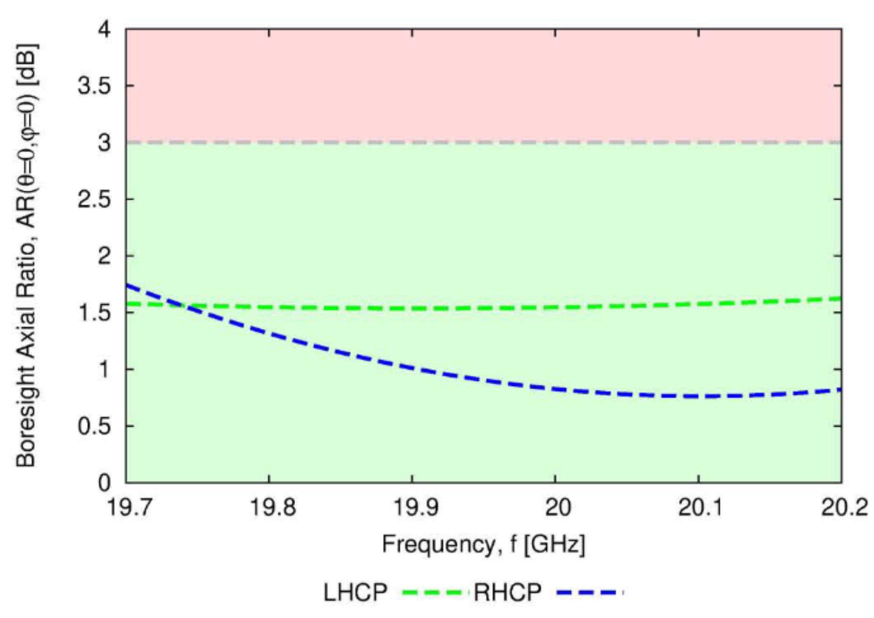
(a)



(b)

Customizable Phased Array Antenna based on Domino Tiles for Satcom Applications (3/8)





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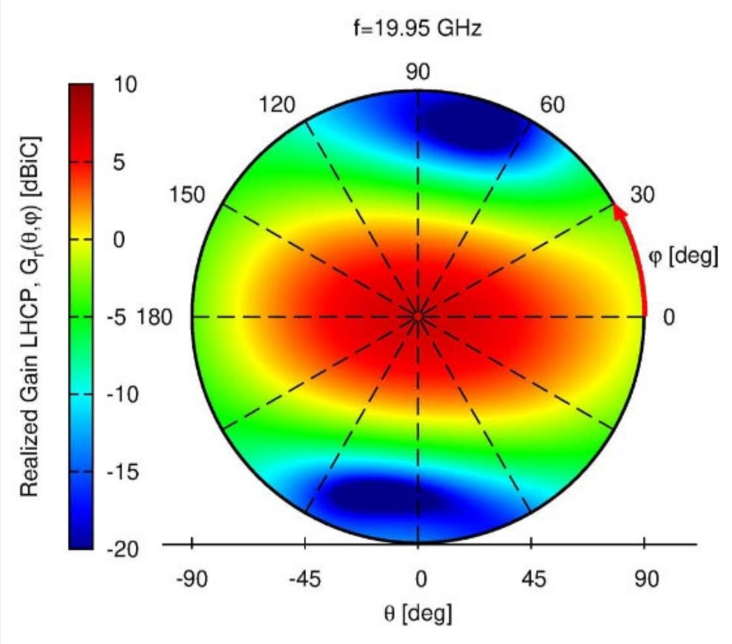
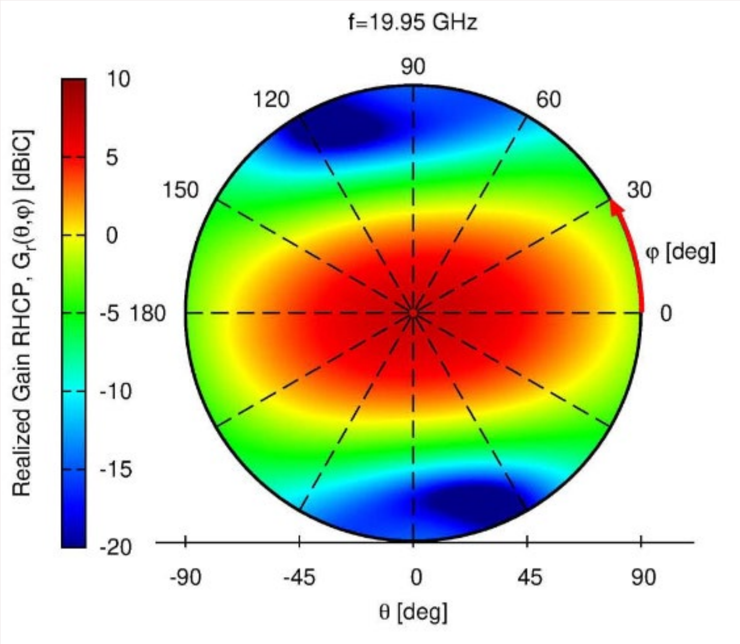
Customizable Phased Array Antenna based on Domino Tiles for Satcom Applications (4/8)





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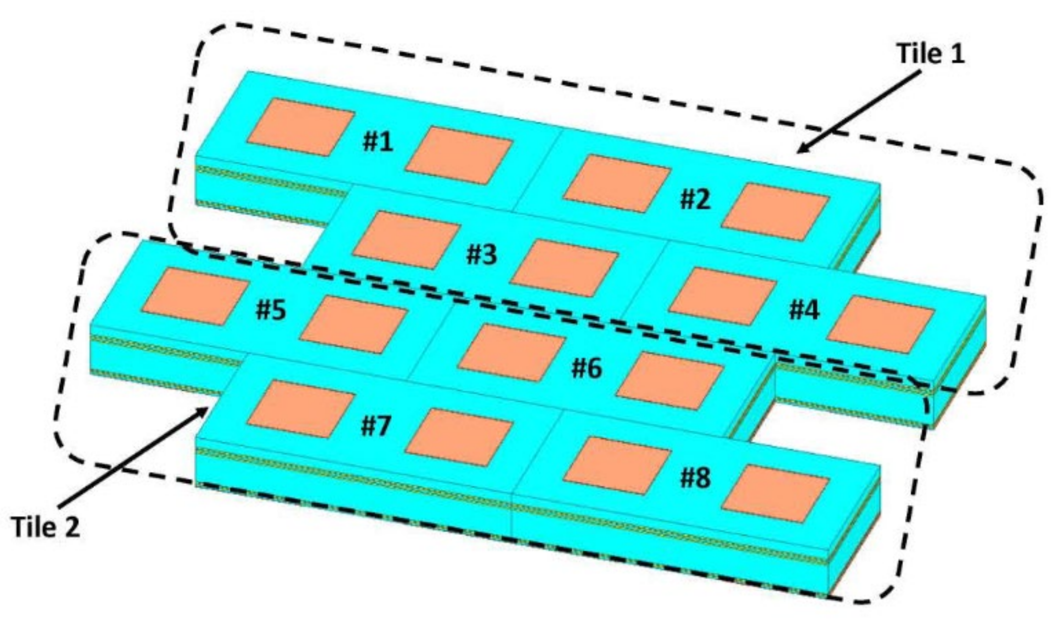
Customizable Phased Array Antenna based on Domino Tiles for Satcom Applications (5/8)



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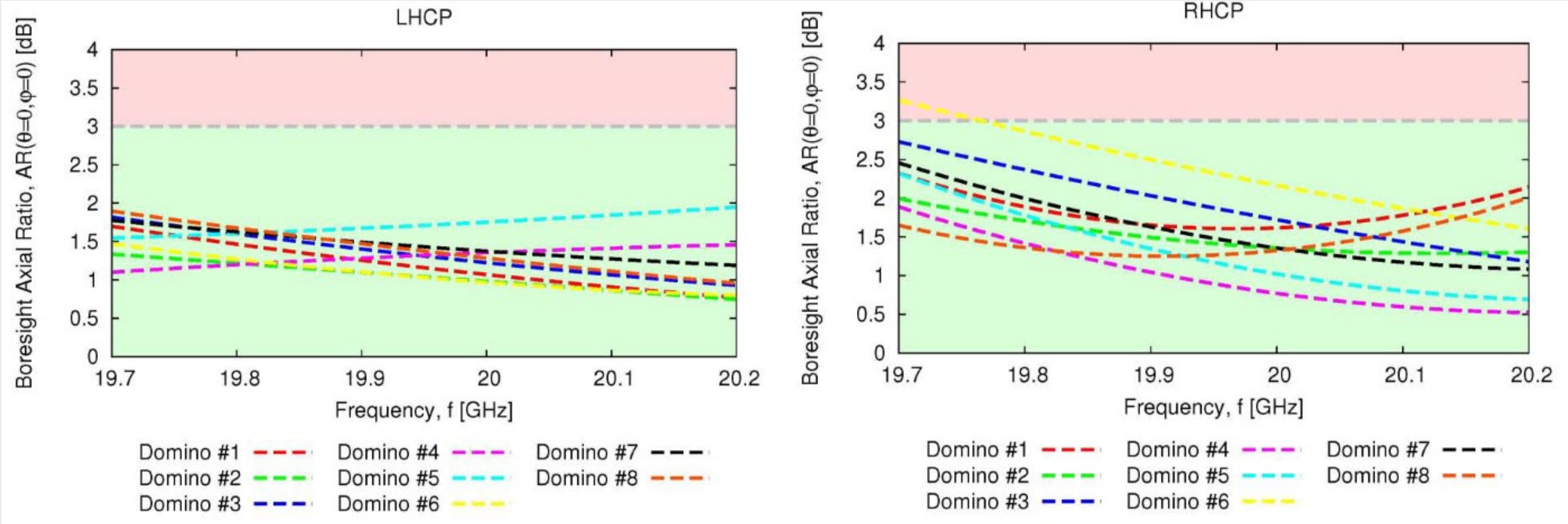
Customizable Phased Array Antenna based on Domino Tiles for Satcom Applications (6/8)



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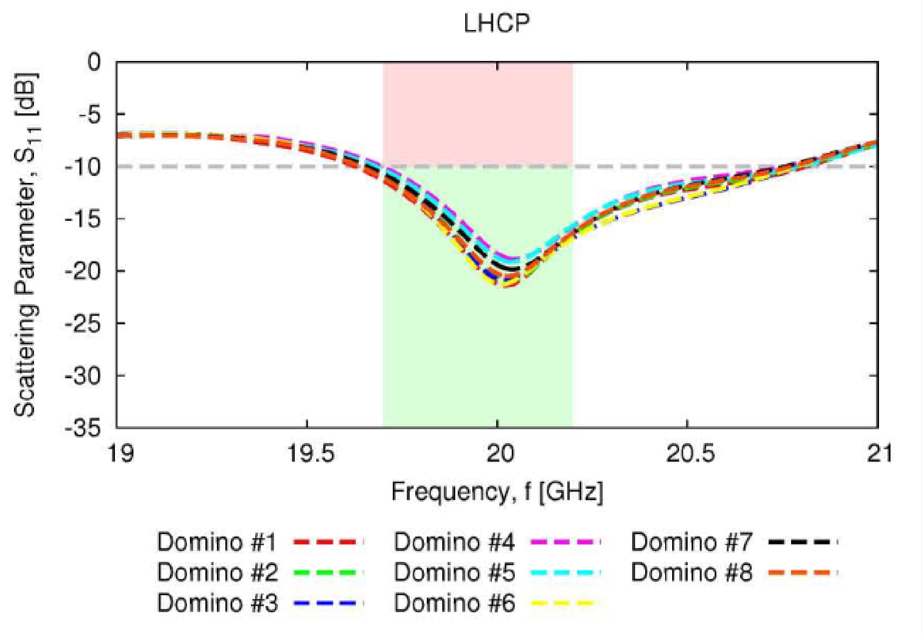
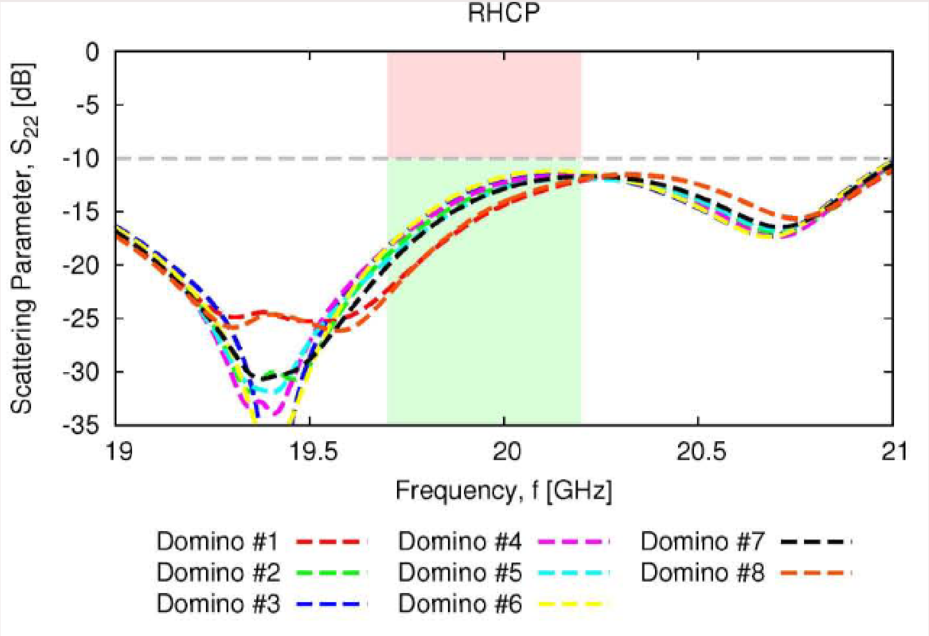
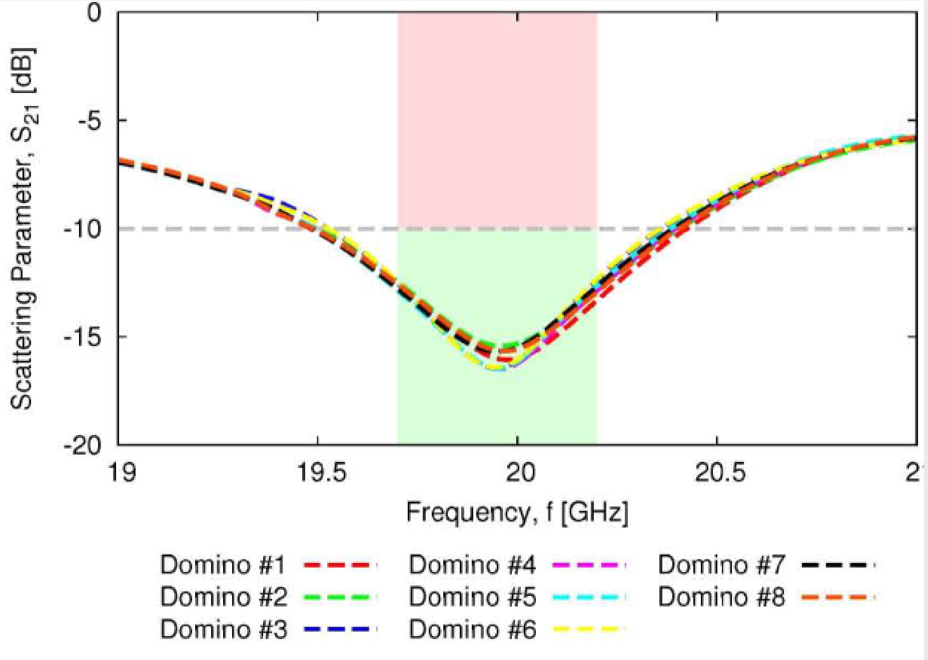
Customizable Phased Array Antenna based on Domino Tiles for Satcom Applications (7/8)

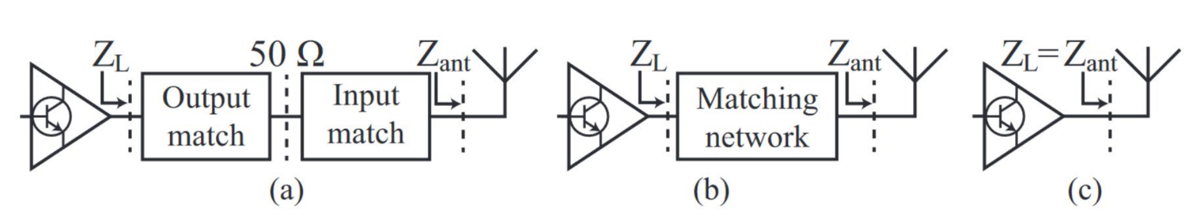


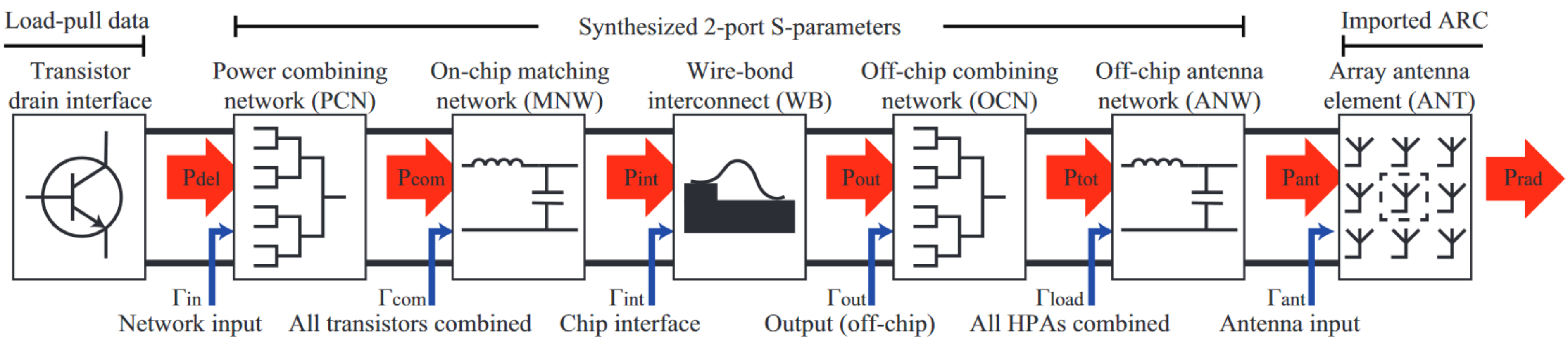


Customizable Phased Array Antenna based on Domino Tiles for Satcom Applications (8/8)



Direct Matching of HPA and Antenna (1/5)





M. de Kok, et al, “Modeling Integrated Antennas and Unisolated High-Power Amplifiers in Infinite Scanning Arrays,” In *2023 European Microwave Conference*

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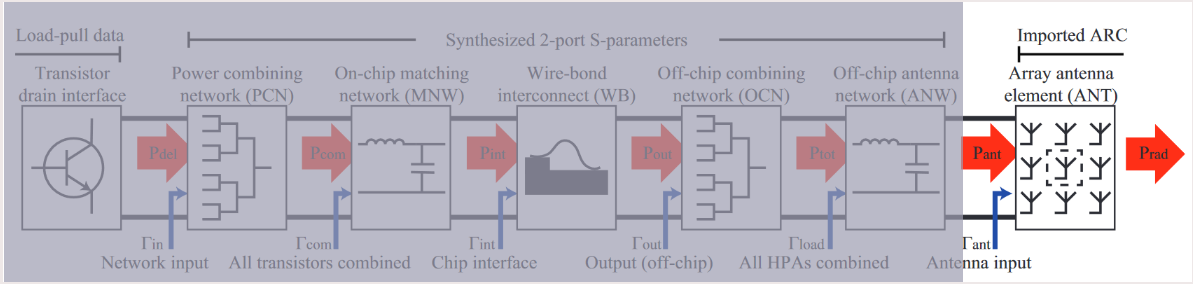
TU/e

Direct Matching of HPA and Antenna (2/5)



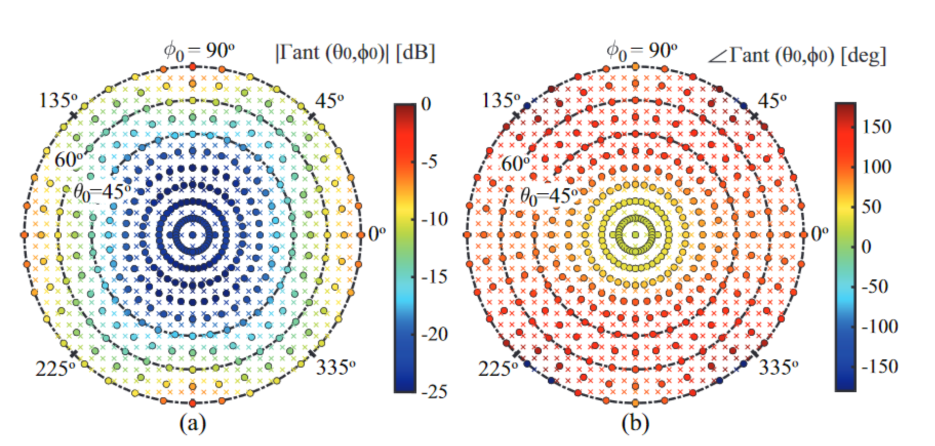
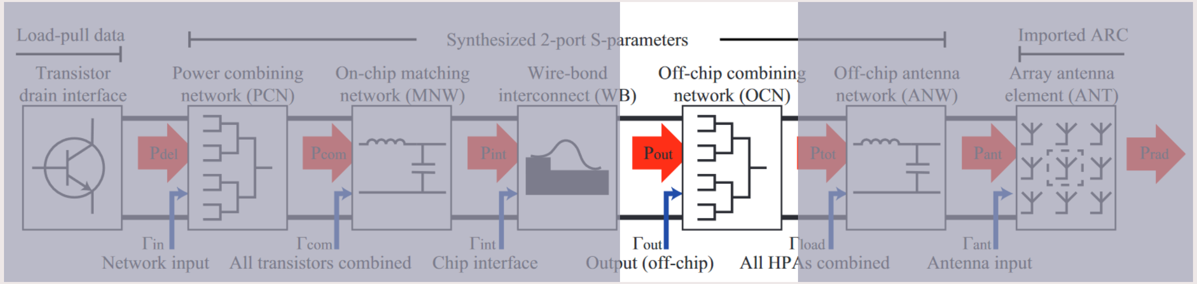


Fig. 3. Simulated (o) and interpolated (x) active reflection coefficient magnitude (a) and phase (b) of a 50 Ω-matched stacked-patch antenna in an infinite array for sampled scan angles within 75° from broadside.

M. de Kok, et al, "Modeling Integrated Antennas and Unisolated High-Power Amplifiers in Infinite Scanning Arrays," In *2023 European Microwave Conference*

Direct Matching of HPA and Antenna (3/5)



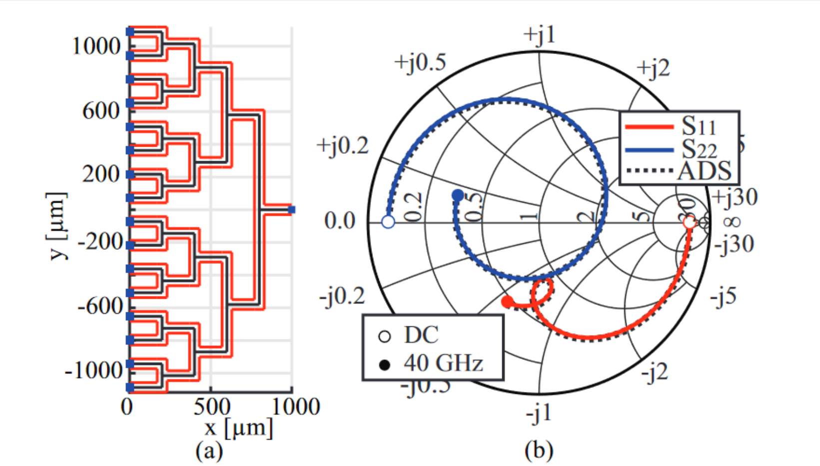
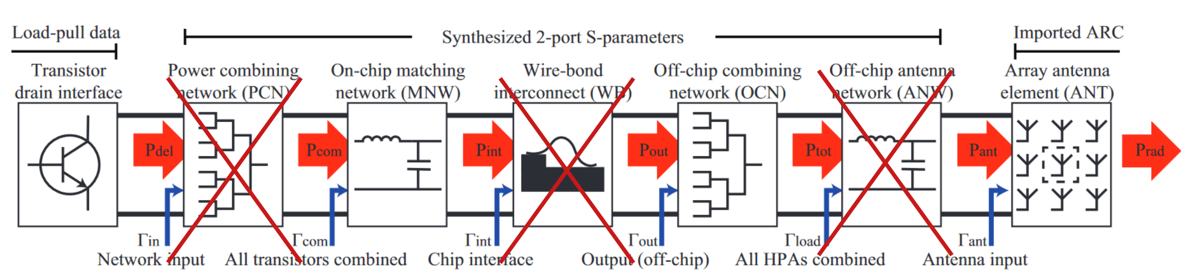


Fig. 4. (a): Schematic of a synthesized 16:1 combiner network. (b): Calculated active S_{11} and S_{22} results, compared against ADS simulations. Port 1 denotes an individual transistor drain interface, port 2 the common output of the PCN.

M. de Kok, et al, "Modeling Integrated Antennas and Unisolated High-Power Amplifiers in Infinite Scanning Arrays," In *2023 European Microwave Conference*

Direct Matching of HPA and Antenna (4/5)



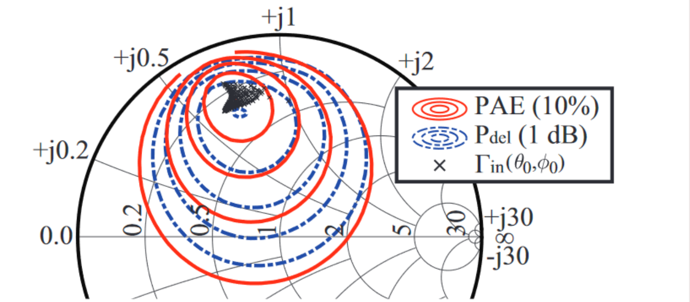


Fig. 6. Varying values of Γ_{in} due to scanning to angle (θ_0, ϕ_0) within 75° from broadside, projected onto interpolated load-pull contours.

M. de Kok, et al, "Modeling Integrated Antennas and Unisolated High-Power Amplifiers in Infinite Scanning Arrays," In *2023 European Microwave Conference*

Direct Matching of HPA and Antenna (5/5)

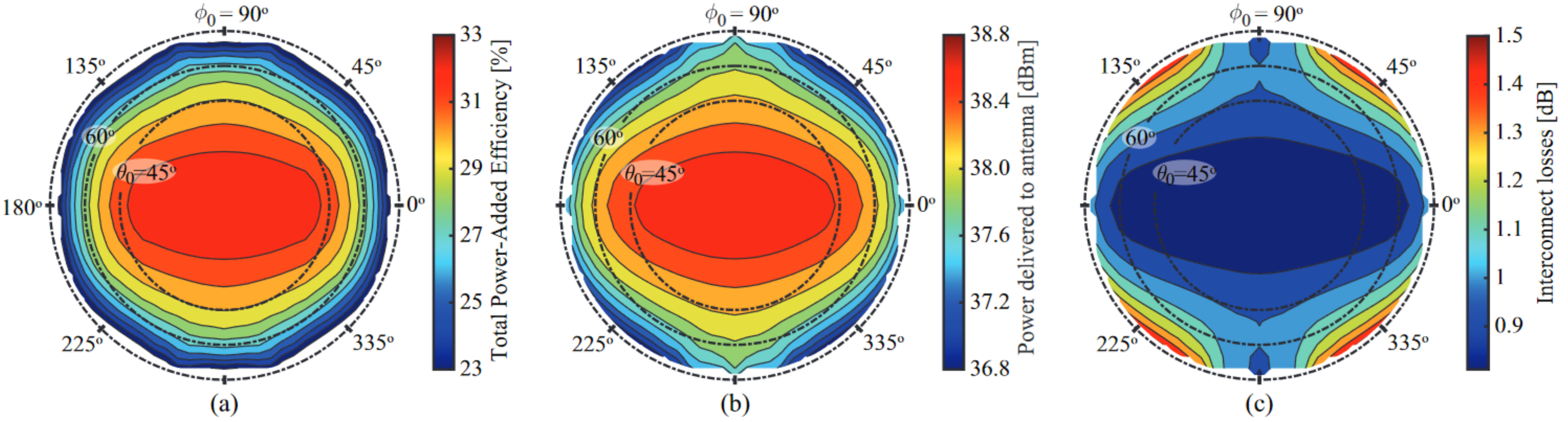


Fig. 7. Model results for a 30 GHz 50 Ω stacked-patch element in an infinite array, connected to an eight-transistor GaN HPA with a synthesized PCN, a single on-chip L-shaped MNW, and a 500 μm bondwire. In (a) and (b), the total PAE and P_{ant} values are mapped to their respective scan angles (θ_0, ϕ_0) within 75° from broadside. The total mismatch and network losses between the Γ_{in} and Γ_{ant} interfaces are plotted for each scan angle in (c).

M. de Kok, et al, “Modeling Integrated Antennas and Unisolated High-Power Amplifiers in Infinite Scanning Arrays,” In *2023 European Microwave Conference*

Thank You!