TNO VIEW ON 6G
ONE6G SUMMIT - NOV 2021 | TOON NORP

REVENUE ORGANISATION TNO (INCL. GOVERNMENT GRANT)

540.1 MILLION EURO

48%

52%

- GOVERNMENT GRANT
- MARKET AND GOVERNMENT SALES

+1%
534.5 MILLION EURO 2019
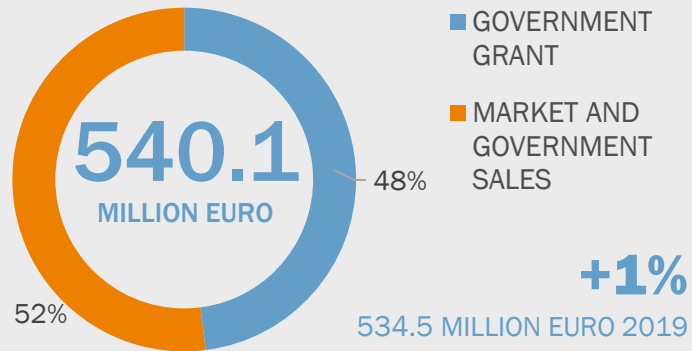
NUMBER OF EMPLOYEES

3,562 TOTAL

**3,431** 2019

HEALTHY LIVING
'Promoting healthy working and living'

TRAFFIC & TRANSPORT
'Making livable and sustainable cities a reality'

INFORMATION & COMMUNICATION TECHNOLOGY
'Charting and accelerating the digital transformation'

ARTIFICIAL INTELLIGENCE
'AI Technology and Applications'

DEFENCE, SAFETY & SECURITY
'We're putting our knowledge and technology to work for safety and security'

ENERGY TRANSITION
'Accelerating the Energy Transition'

INDUSTRY
'Innovating for employment, prosperity and well-being'

BUILDINGS, INFRASTRUCTURE & MARITIME
'Robust constructions, sustainable use'

CIRCULAR ECONOMY & ENVIRONMENT
'Directing and accelerating sustainability'

STRATEGIC ANALYSIS & POLICY
'Turning complex issues into sustainable innovations'

› TNO is an independent research organisation in the Netherlands that focuses on applied science.

NETWORKS DEPARTMENT

Cloud infrastructure

TNO networks

Radio Access

Cloud based core

TNO innovation for life
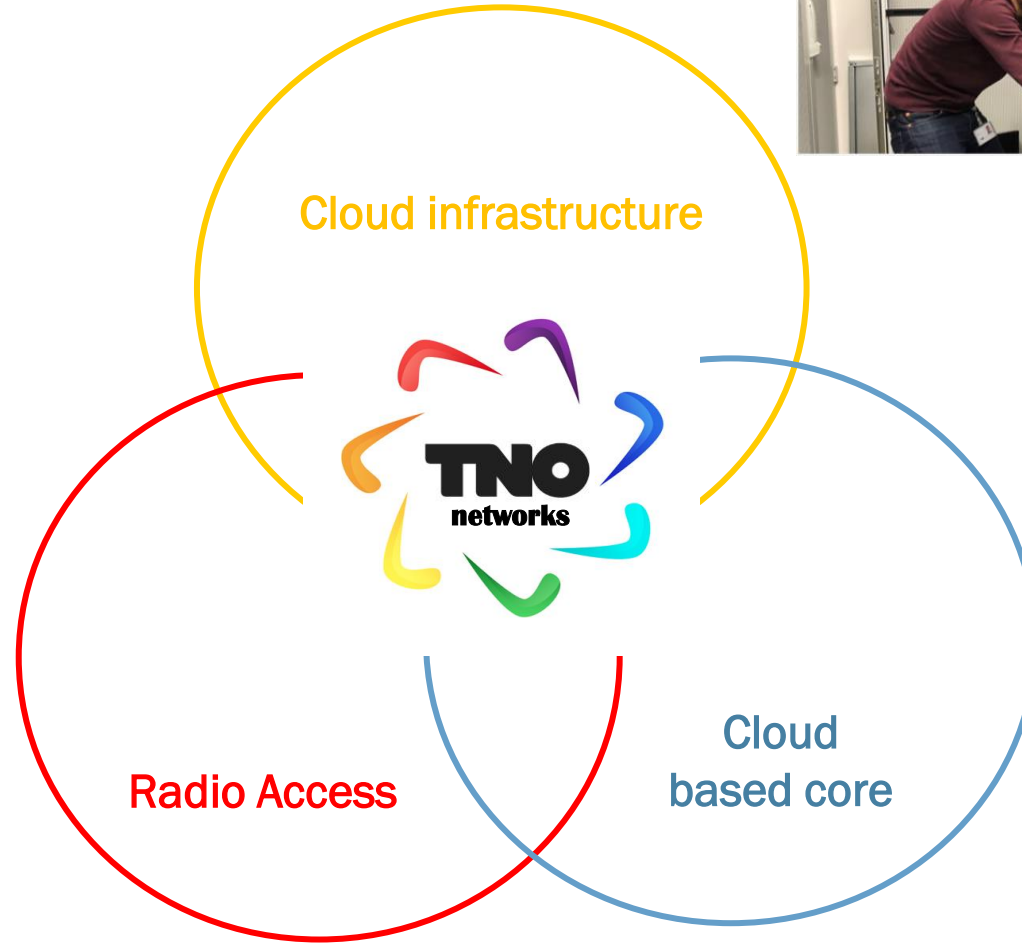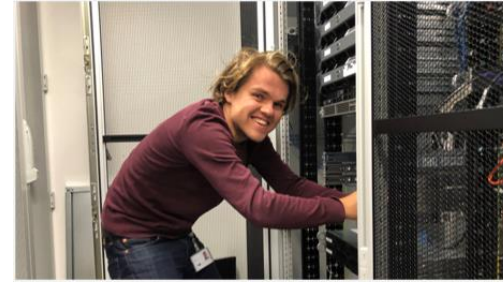
MORE DATA WITH EACH NEW GENERATION

1G
2G
3G
4G
5G
6G

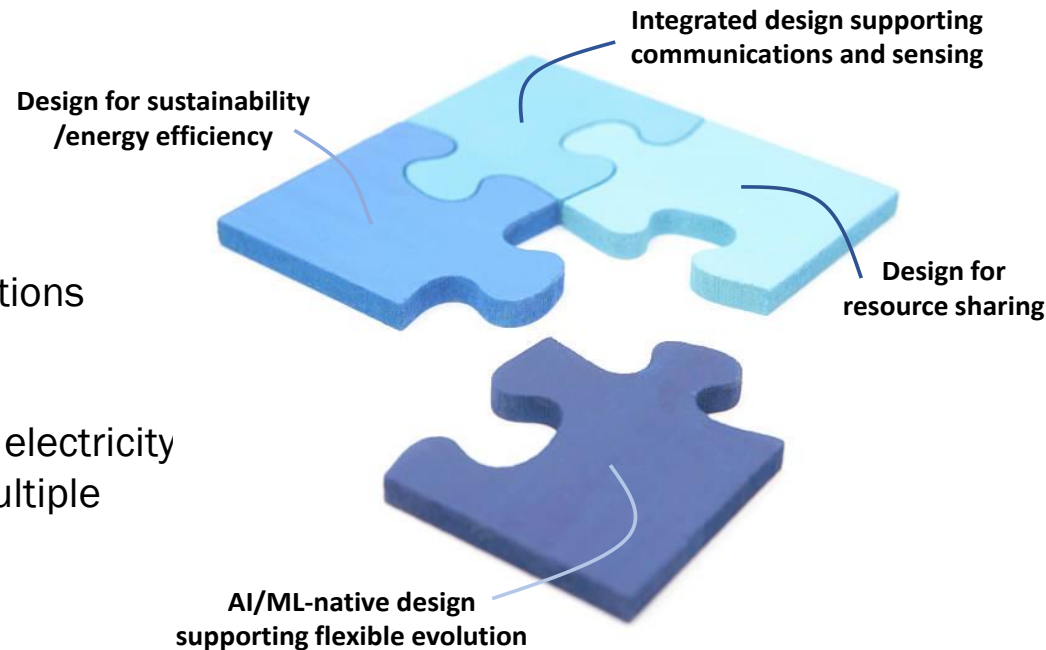TNO view on 6G

THE INDOOR CHALLENGE

High data rate applications mostly indoors

- An important challenge is going to be the use of THz frequency bands in an environment that is not very radio friendly

- Ultra massive MIMO beamforming

- Cell free networking

- Ultra dense networks

- Highly dynamic environment

- AI/ML based resource management

High data rate and capacity at higher frequencies

↓

Propagation at high frequencies is a challenge

↓

Indoor basestations

6G DESIGN CRITERIA

› Energy efficiency is crucial

  › Goal should at least be to keep energy consumption equal in light of growing data volumes, more devices and more base stations

› 6G needs to support resource sharing

  › Like with other infrastructures (road, train, electricity it becomes increasingly difficult to have multiple infrastructures in parallel everywhere

› Integrating sensing gives new possibilities

  › From localisation to sensing and cognition
  › Optimising the radio link by sensing the environment
  › Both radar and communication use array antennas and beamforming

› Radio becomes AI-native software in an open architecture

  › No separation of radio access network and core network
  › Flexible evolution by updating software components

Design for sustainability /energy efficiency

Integrated design supporting communications and sensing

Design for resource sharing

AI/ML-native design supporting flexible evolution

CONNECTED INTELLIGENCE

› Immersive communication, cognition and twinning, imply virtual representations in the digital world of entities in the physical and human world

› These virtual representations have dynamic relations with sensors, actuators, screens and cameras

› Connections between virtual representations in the digital world replace connections between mobile end-devices

› Fundamental impact on the mobile network

> Scalability of virtual representations

> Identification of virtual representations replaces identification of mobile devices

Digital World

Connected Intelligence

Twinning Control

Immersive communication Cognition

6G

Physical World   Human World
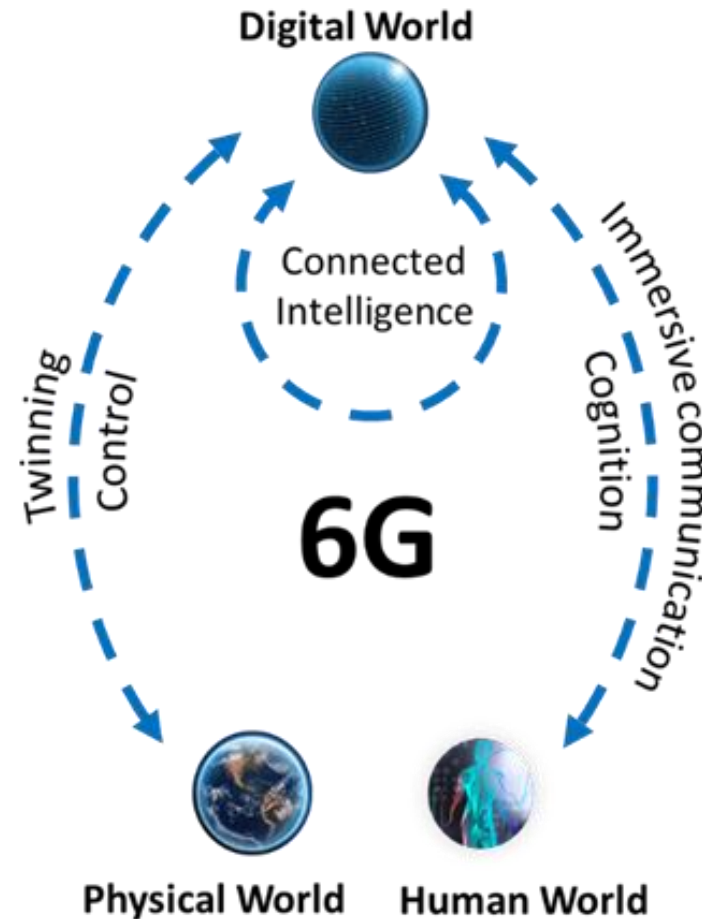
IN CONCLUSION
SOME BOLD STATEMENTS ☺

› There may not be room for both 6G and WiFi

› If we do it right 6G can be the final generation

› 6G will be the death of the smart phone

TNO innovation for life

THANK YOU FOR
YOUR TIME

Links:
https://5g-ppp.eu/wp-content/uploads/2021/06/WhitePaper-6G-Europe.pdf

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