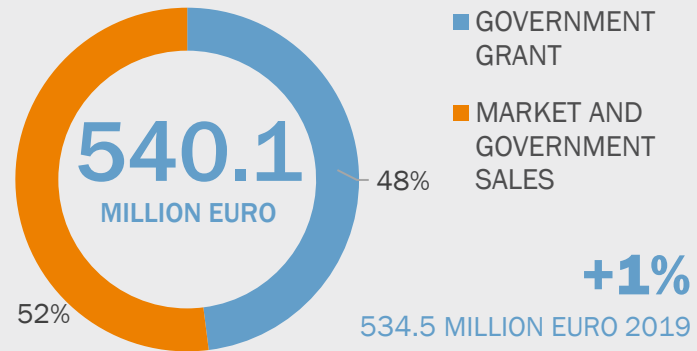


TNO innovation
for life



› **TNO VIEW ON 6G**
VISIONS FOR FUTURE COMMUNICATIONS SUMMIT
TOON NORP

REVENUE ORGANISATION TNO (INCL. GOVERNMENT GRANT)



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.

EACH GENERATION MORE DATA BUT LESS MOBILITY



1G



2G



3G



4G



5G



6G

› THE INDOOR CHALLENGE

High data rate applications mostly indoors

High data rate and capacity at higher frequencies

Propagation at high frequencies is a challenge

Indoor basestations

- › 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



› 6G DESIGN CRITERIA

› Energy efficiency is crucial

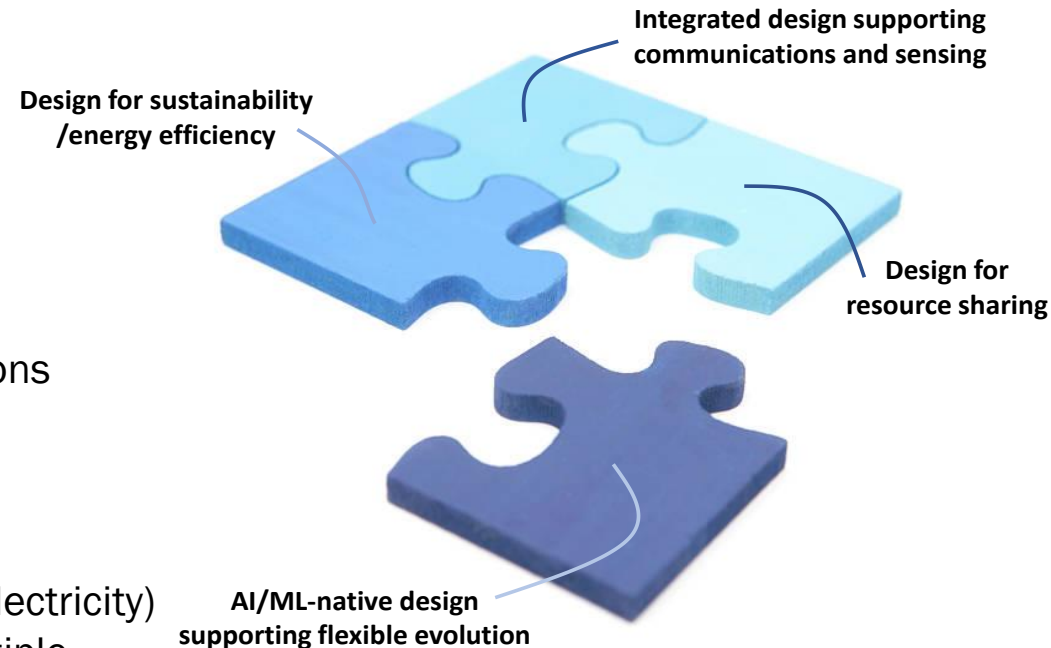
- › Goal should at least be to keep energy consumption equal in light of growing data volumes, more devices and more base stations

› 6G needs to support resource sharing

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

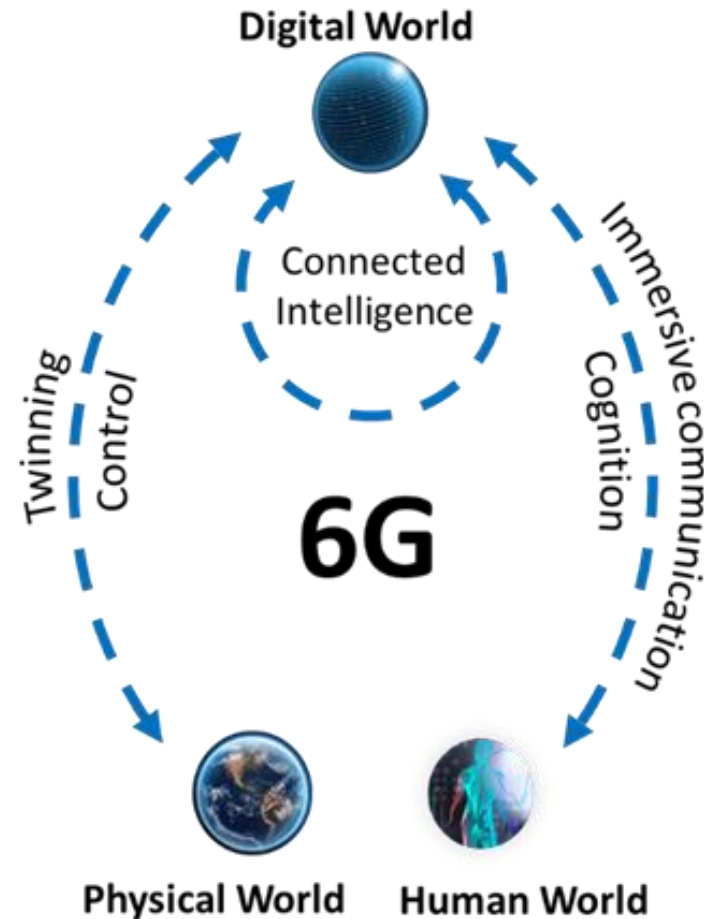
› AI-native software in an open architecture

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



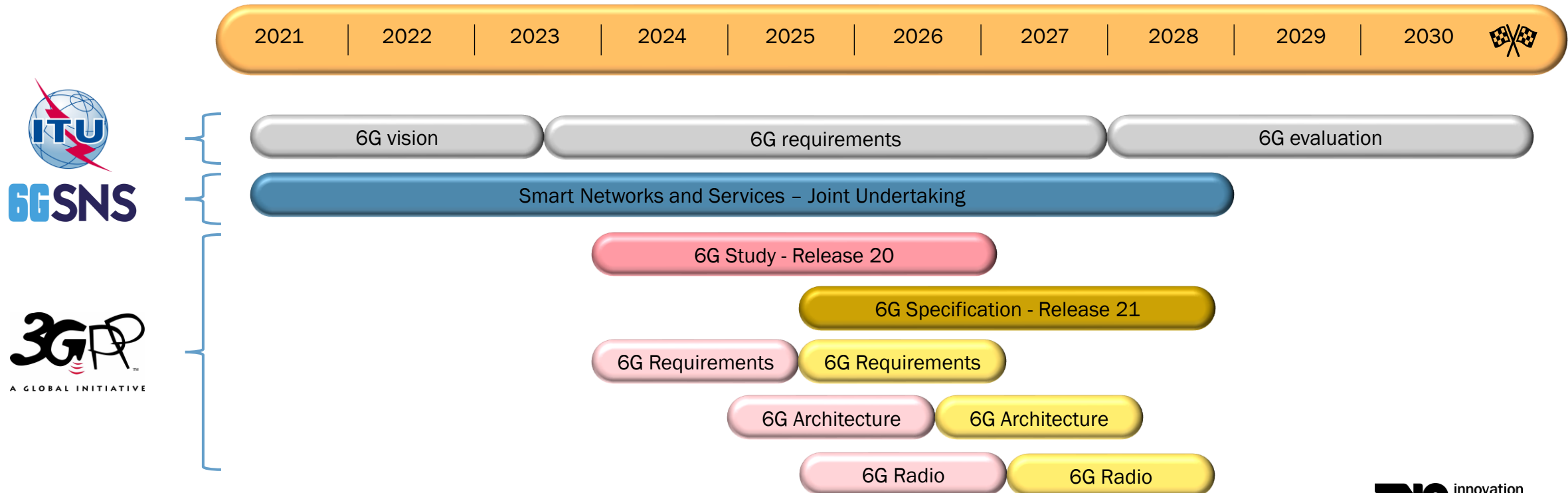
› CONNECTED INTELLIGENCE

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



› 6G STANDARDISATION

- › We expect 3GPP to start on 6G in around 2024
 - › Release 20 will be 6G studies, Release 21 will be first normative 6G specification
 - › Each release starts with requirements, followed by architecture and radio architectural aspects



› **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
- › Smart agents replace the smart phone as the representation of persons in mobile communication

› **THANK YOU FOR
YOUR TIME**

Links:

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



Toon Norp
+31 6 20010212
toon.norp@tno.nl

TNO innovation
for life