

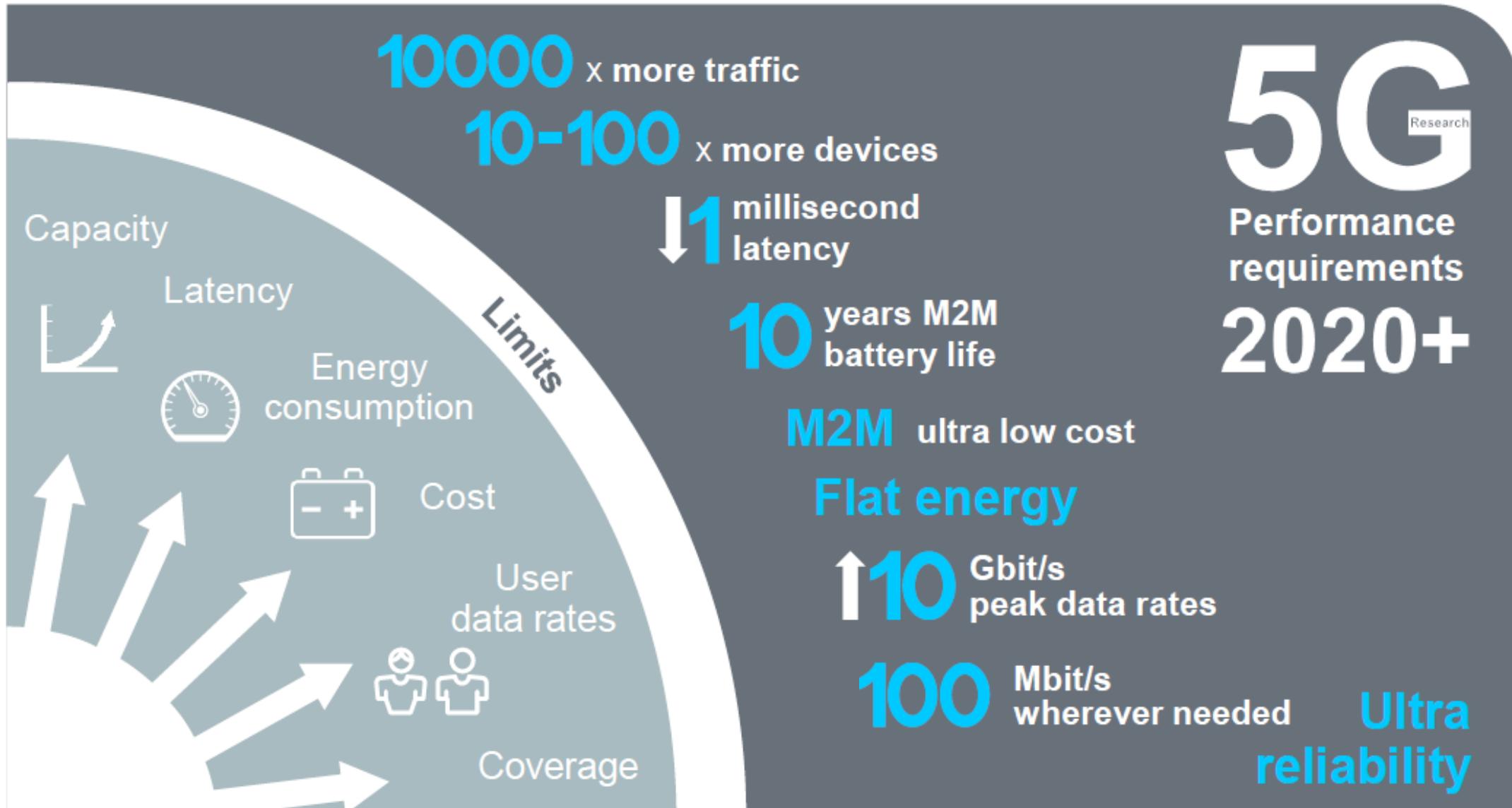
European and National 5G Research for Transportation Systems

An Overview

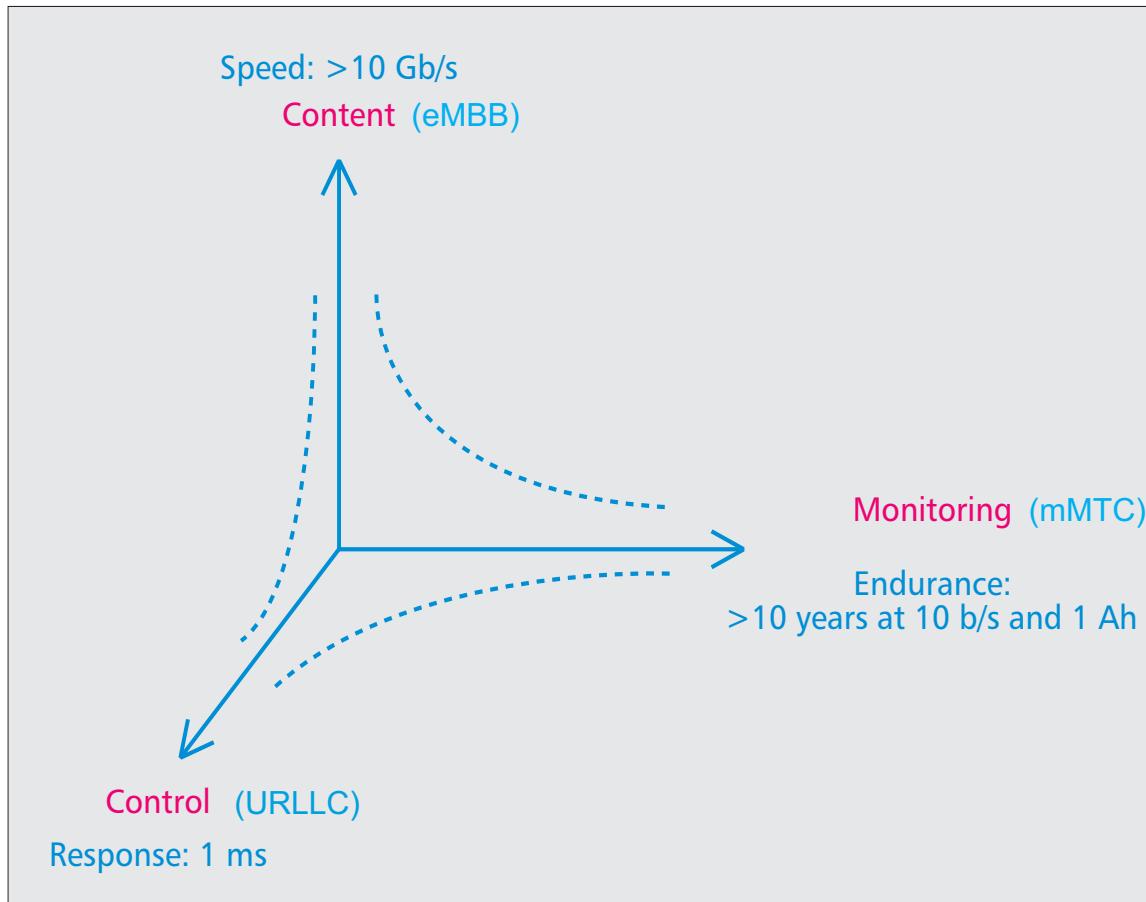
Thomas Zemen, AIT



5G TARGETS



5G – THREE SYSTEMS IN ONE



5G network slices

- eMBB, enhanced Mobile Broad band
- mMTC, massive machine type communication
- URLLC, ultra reliable low latency communication

❖ G. Fettweis, S. Alamouti, “5G: Personal mobile internet beyond what cellular did to telephony,” IEEE Commun. Mag., Feb. 2014.

NEW 5G TECHNOLOGIES

1. Massive multiple-input multiple output (MIMO) systems

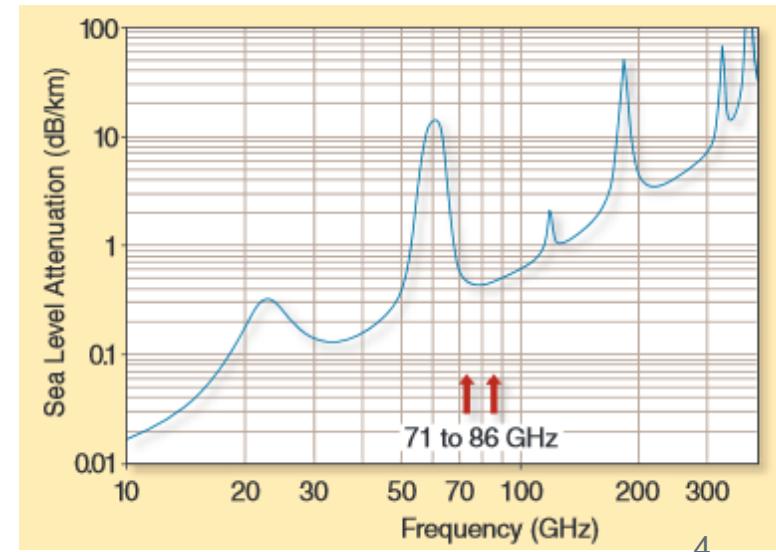
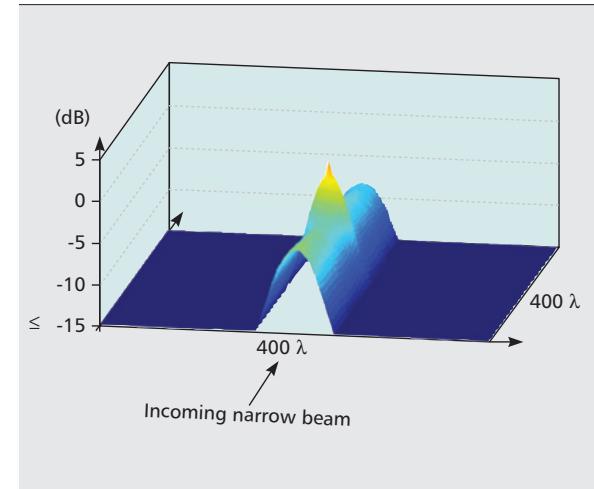
large number of antennas (~100) allow for highly energy efficient transmission

2. Millimeter-wave

frequency band from 30-90GHz allow for large available bandwidth

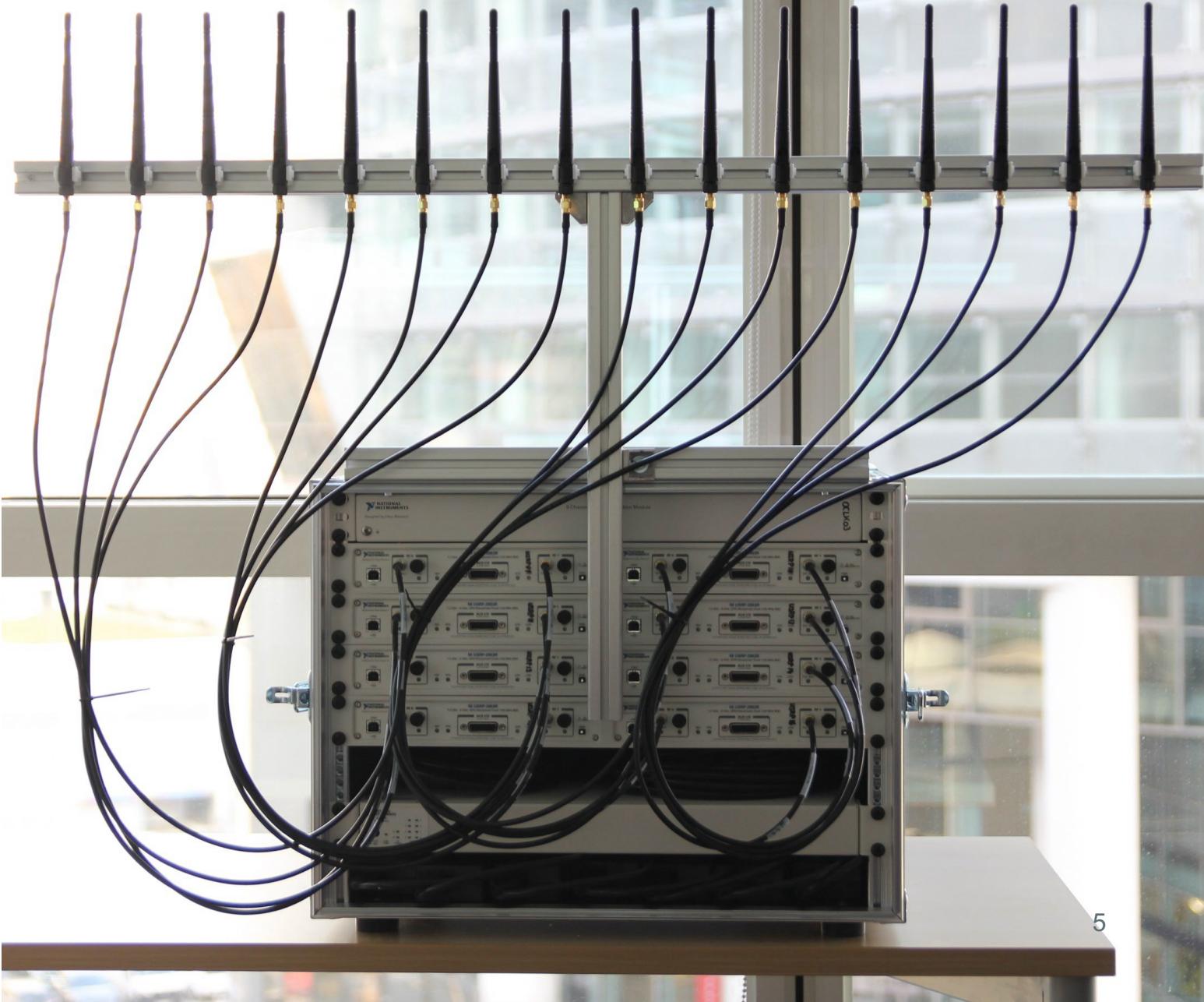
3. Ultra-reliable low-latency wireless links

enable the connection of actuators (vehicles, robots) via wireless links utilizing multiple diversity sources



MASSIVE MIMO @ AIT

- **Massive amount** of antennas (30 – 100)
- **Eliminates fading** and enables **reliable communication**
- **Power efficiency** through transmit power focussing

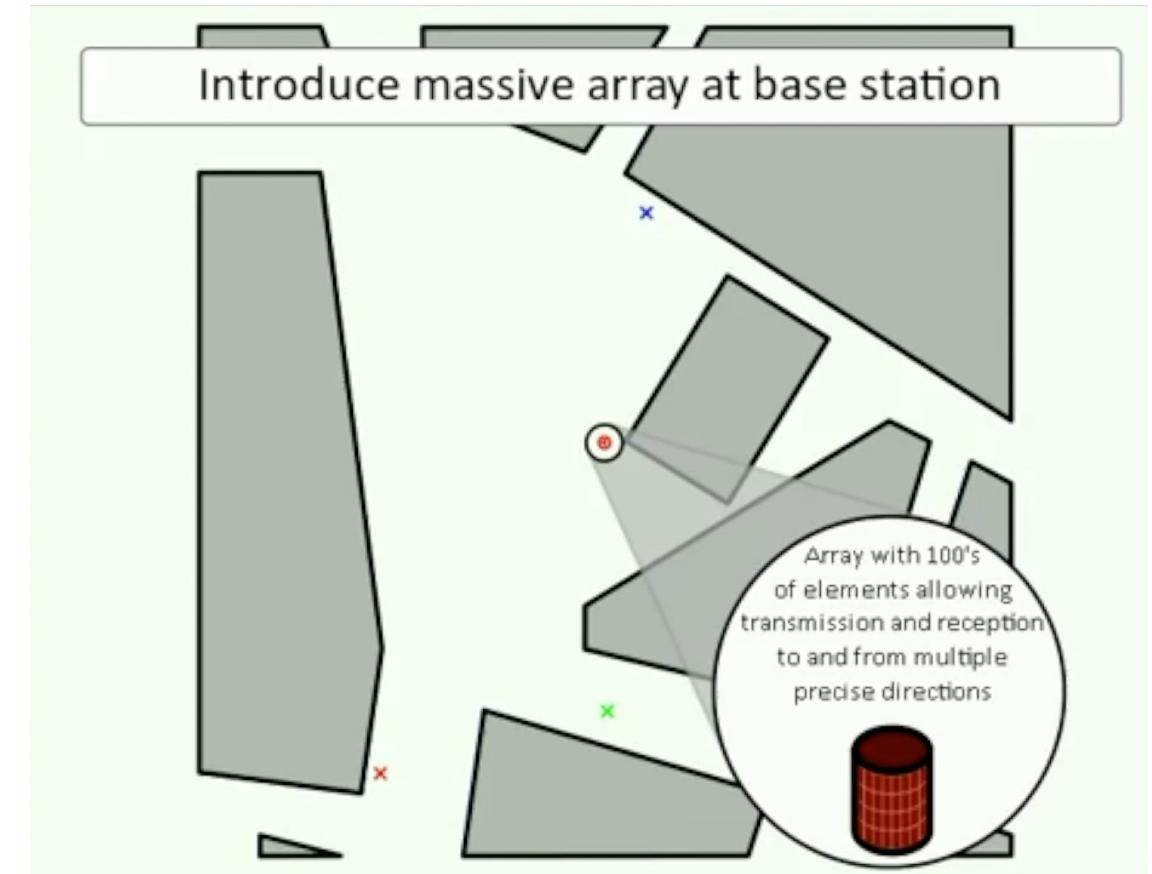


MASSIVE MIMO FOR RELIABLE WIRELESS LINKS

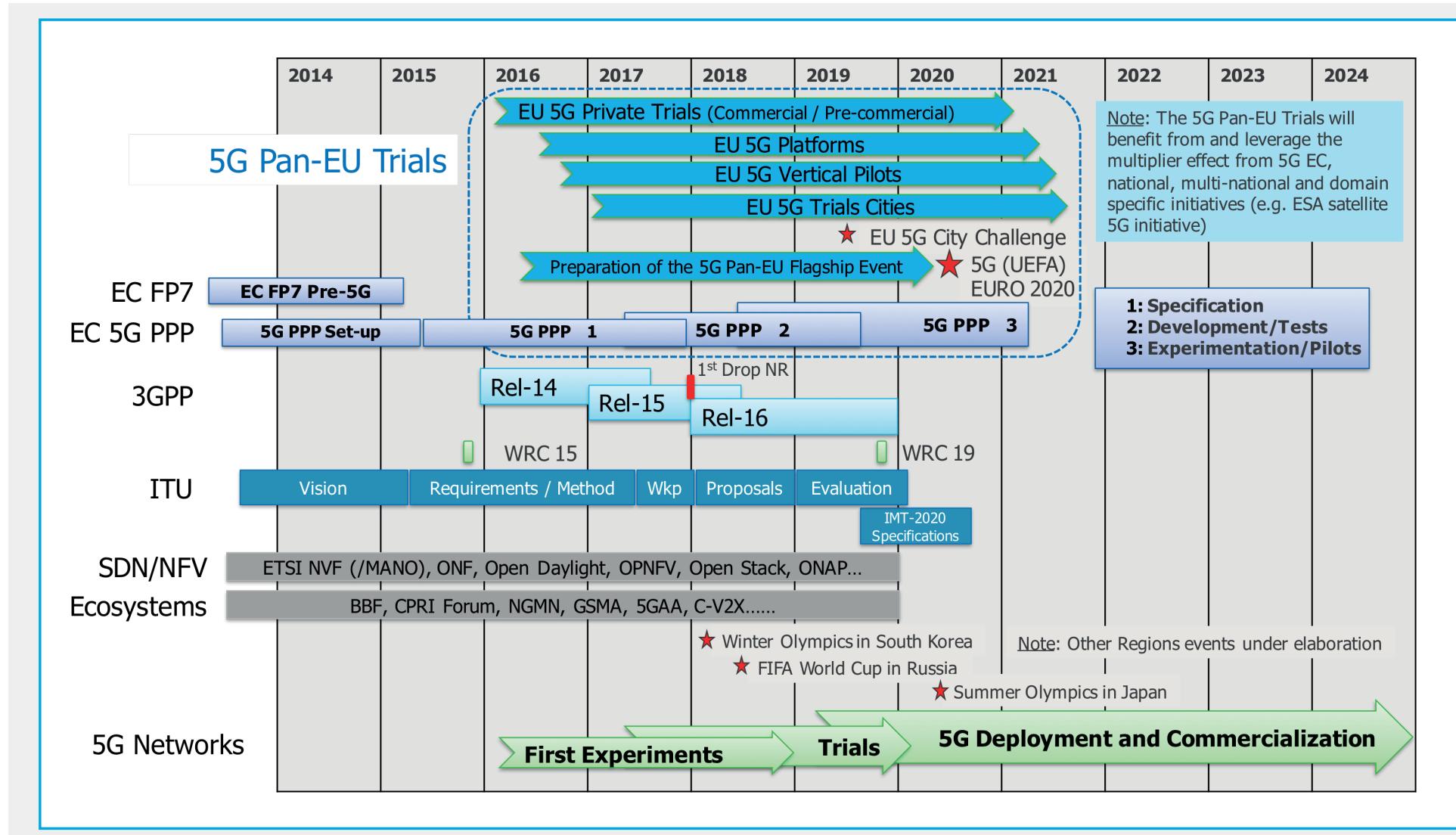
Use wireless channel properties in a clever way!

- **Massive MIMO**

- Large number of antennas
- Precise beam forming to users



5G TIMELINE – RESEARCH, TRIALS, STANDARDS



EUROPEAN 5G-PPP PHASE 2 PROJECTS

- **Radio access** - URLLC, satellite, broadcast, multicast
- **Optical** - access, backhaul and core network, wireless interfaces
- **Networking and vertical industrial use cases**
- **Network slicing and edge computing**
- **SDN, NFV and Services**



AUSTRIAN 5G RESEARCH LANDSCAPE (I)

Sources: projekte.ffg.at, cdg.ac.at

- **TU Wien**
 - **CD Lab** „Dependable Wireless Connectivity for the Society in Motion“, S. Schwarz
- **Salzburg Research**
 - **5G-MLab** (FFG): IP-layer reliability characterization, M. Herrlich
 - **TriCePS** (FFG): Quality of Service for the application layer in CPS communication
- **JKU Linz**
 - **CD-Lab** „Digitally Assisted RF Transceivers for Future Mobile Communications“, A. Springer
 - **TARANTO** (H2020): Heterojunction Bipolar Transistors for 600GHz
- **TU Graz**
 - **DeSSnet** (K-Projekt): Dependable, secure and time-aware sensor networks

AUSTRIAN 5G RESEARCH LANDSCAPE (II)

- **AIT Austrian Institute of Technology**
 - **MARCONI** (FFG)
Massive MIMO for Reliable 5G Vehicular Communications, T. Zemen
 - **UNWIRE** (FFG)
Replacing cables with radio communication links in industrial production lines, T. Zemen
 - **SCOTT** (H2020)
Secure COnnected Trustable Things – Virtual coupling of high speed trains, T. Zemen
 - **ENBALE-S3** (H2020)
Repeatable testing of wireless connected autonomous vehicles, T. Zemen
 - **TRITON** (FFG): Heterogeneous Integration of Millimeter-Wave Technology – chip design for optical/mmWave interfaces, B. Schrenk

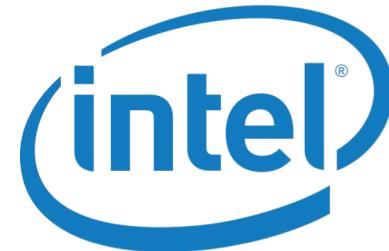
INDUSTRIAL 5G LANDSCAPE IN AUSTRIA



NOKIA

amico

NXP



SIEMENS

AT&S



A1
Telekom
Austria
Group



CISC
semiconductor



KATHREIN
Antennen - Electronic

5G RESEARCH @AIT: ULTRA-RELIABLE WIRELESS COMMUNICATIONS

Connected autonomous vehicles



Industry 4.0



Transport



Technologies:

- software defined radio
- massive MIMO
- mm-Wave
- remote radio heads
- wireless signal processing

Goals

- real-time - low latency (1ms)
- high reliability
- scalability
- low energy
- new capacity – frequency bands (28GHz+)

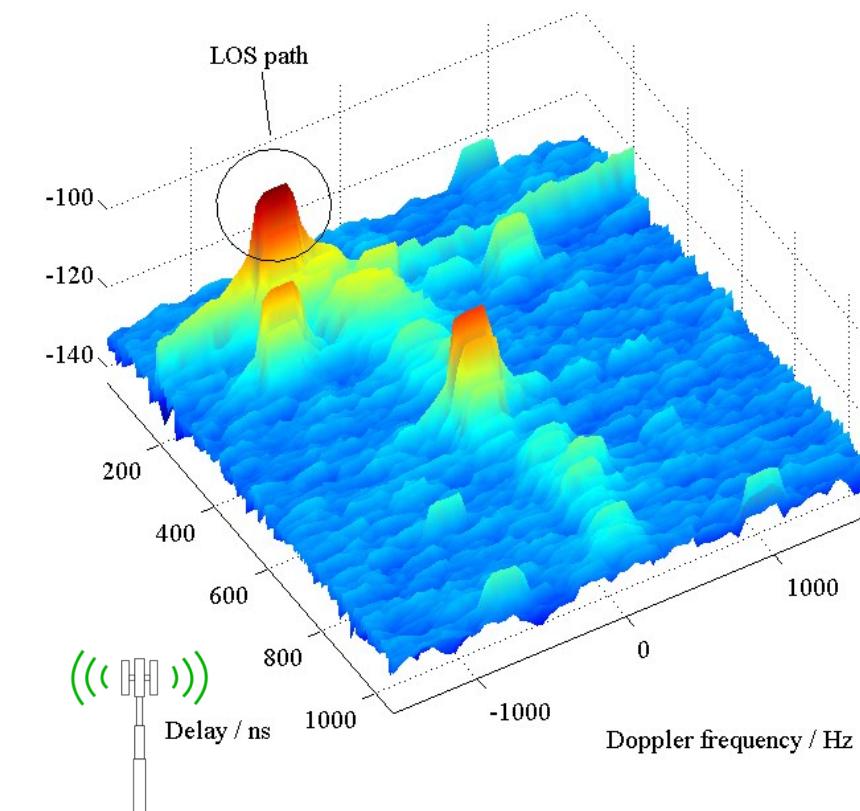
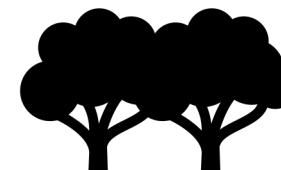
Research focus

- wireless channel characterization
- real-time channel emulation
- low-complexity transceiver algorithms
- rapid prototyping

MARCONI - MOBILITY-AWARE MASSIVE MIMO

- Learn channel U1 + mobility
- Learn channel U2 + mobility
- Inverse + account for mobility

Enables **high-mobility use-cases**
with **high reliability**



CONCLUSION

- **Targeted European 5G research effort in H2020**
- **Austrian research projects focus on Austrian industry needs**
 - Chip design, network operation, vertical URLLC use cases
 - **Mobility-awareness** is key research focus at **AIT**
- **Early 5G deployments will not stop research and development**
 - Continuous addition of new 5G features, applied research support needed
- **URLLC has strong impact on vertical industries** creating **new business models**
 - Connected autonomous vehicles
 - Transportation
 - Industry 4.0
- **Frequency allocation** (auctions) needs to take **new business models** into account (e.g. dedicated spectrum for industry)

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

your ingenious partner

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Wireless Team



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B. Rainer



G. Humer



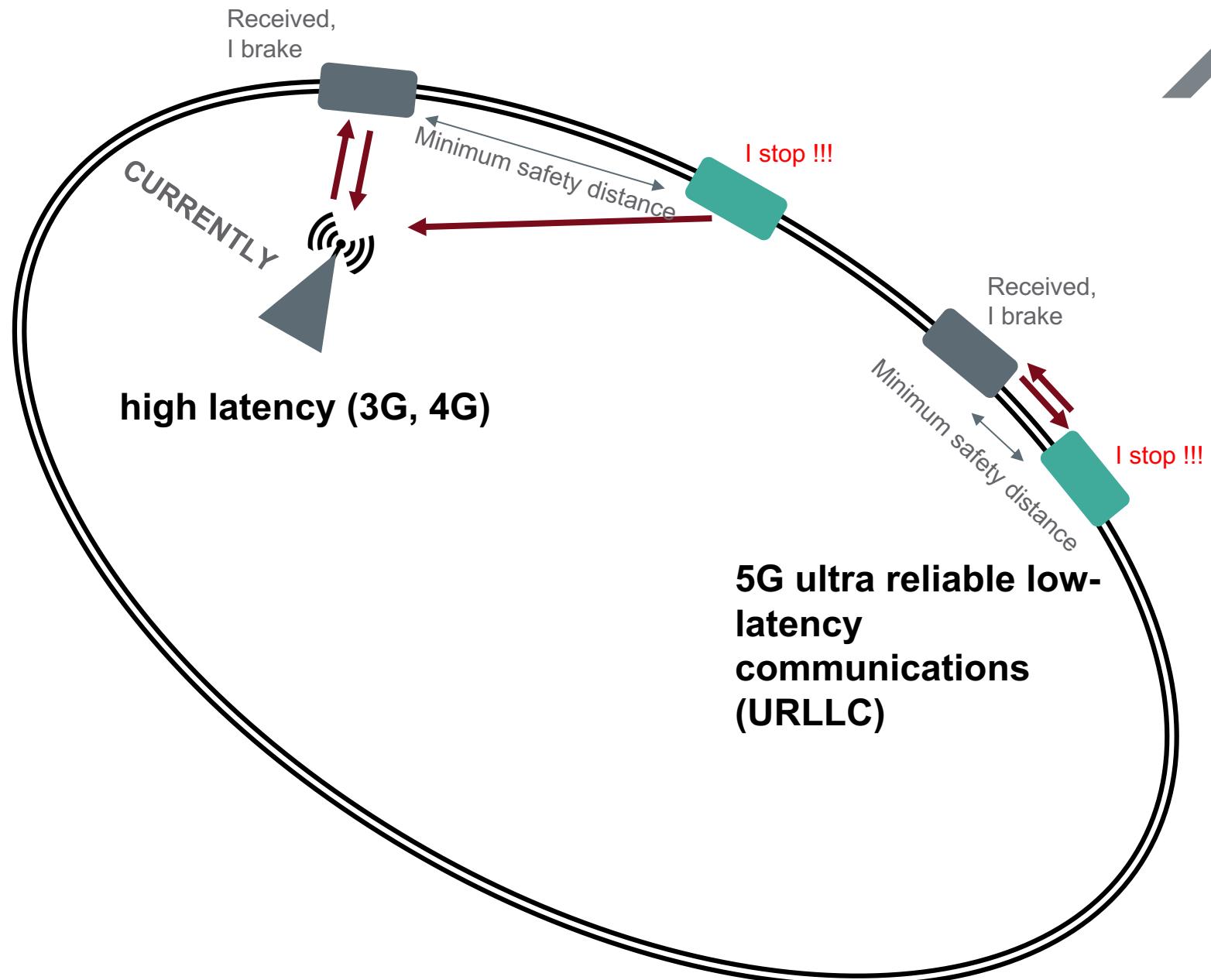
BACKUP

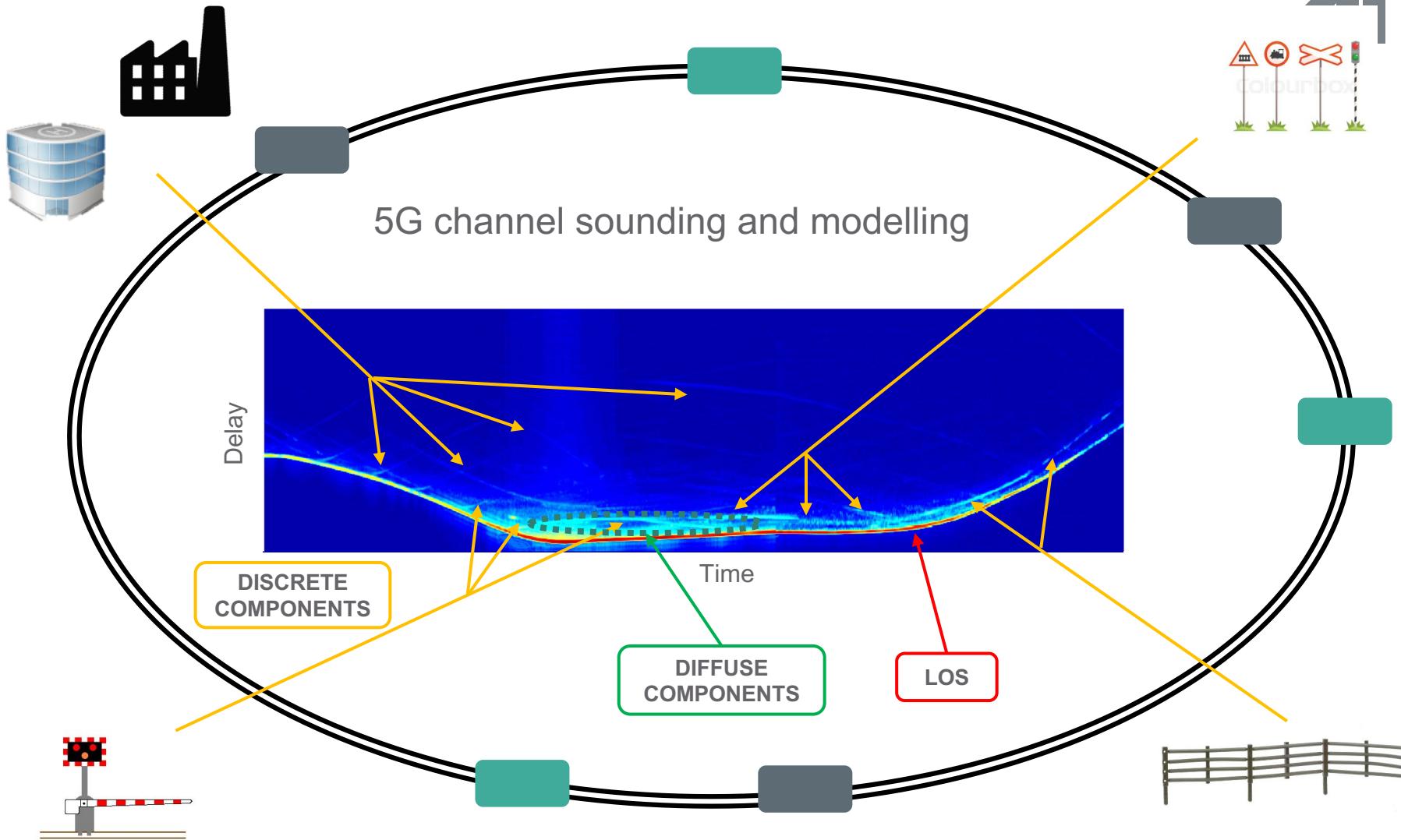


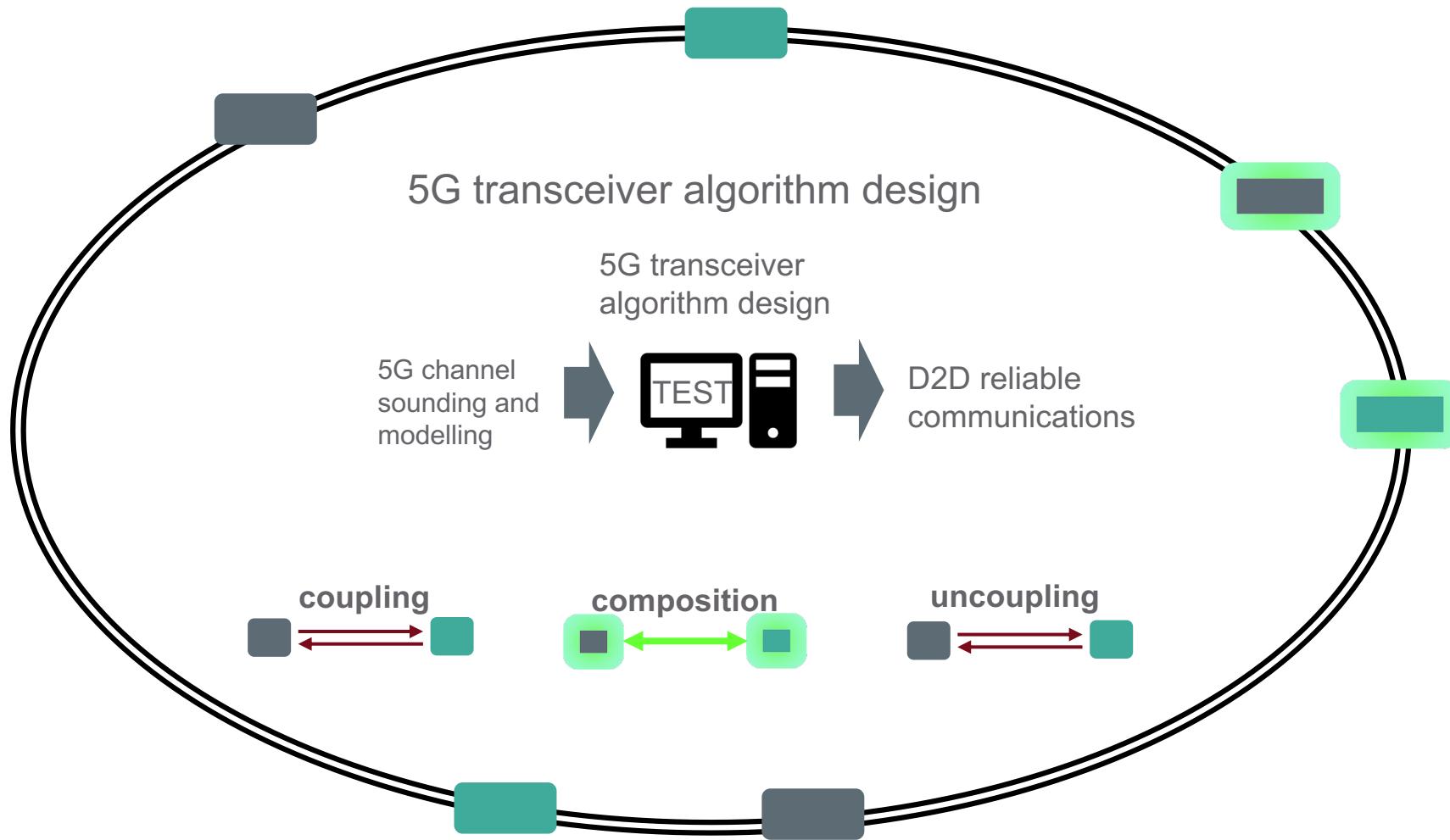
VIRTUAL COUPLING OF HIGH-SPEED TRAINS

SCOTT









EUROPEAN 5G-PPP PHASE 2 PROJECTS WIRELESS RADIO ACCESS NETWORK

- ONE5G – End-to-end 5G new radio improvements
<https://one5g.eu/>
- SAT5G – Integrate satellites into 5G
<http://sat5g-project.eu/>
- 5G CAR – Reliable V2X communications
<https://5gcar.eu/>
- Clear5G – 5G for factories-of-the-future (FoF)

OPTICAL/WIRELESS ACCESS NETWORK

- BLUESPACE – optical beamforming interface for mmWave,
<https://bluespace-5gppp.squarespace.com/>
- IoRL – visible light communication within building,
<https://iorl.5g-ppp.eu/>
- 5G-PHOS – Optical fronthaul architectures,
<http://www.5g-phos.eu/>
- 5G-Picture – Combine edge computing with optical networks,
<http://www.5g-picture-project.eu/>
- METRO-HAUL – optical SDN/NFV transport network,
<https://metro-haul.eu/>

NETWORKING AND VERTICAL IND. USE CASES

- 5G-Xcast – Broadcast and multicast for 5G
<http://5g-xcast.eu/>
-
- 5G-Transformer – Vertical industry mobile transport and computing platform, <http://5g-transformer.eu/>
- NRG-5 – Communication infrastructure for the energy grid,
<http://www.nrg5.eu/>

NETWORK SLICING AND EDGE COMPUTING

- SLICENET – 5G network slicing framework,
<https://slicenet.eu/>
- 5G City – 5G edge cloud computing and communication,
<https://www.5gcity.eu/>
- 5G ESSENCE – Network management for 5G edge computing, <http://www.5g-essence-h2020.eu/>

SDN, NFV AND SERVICES

- 5G-MEDIA – Virtual network functions for 5G networks
<http://www.5gmedia.eu/>
- 5G-MonNArch – Mobile network slicing using SDN and NFV
<https://5g-monarch.eu/>
- 5G-Tango – Verification and validation of NFV,
<https://5gtango.eu/>
- MATILDA – 5G service framework,
<http://www.matilda-5g.eu/>
- NGPaaS – Platform as a service with telco grade,
<http://ngpaas.eu/>