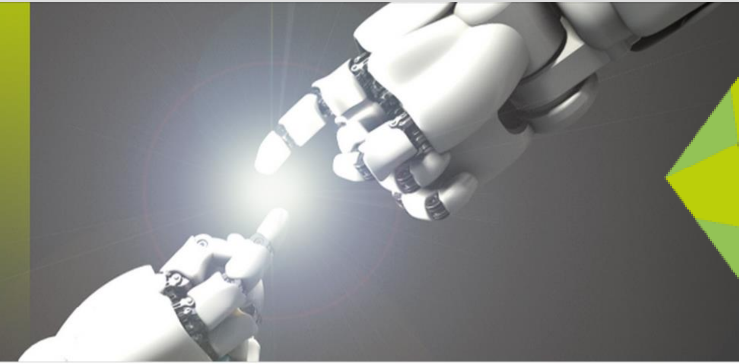
TECHNISCHE UNIVERSITÄT DRESDEN



5G LAB GERMANY

Eine neue Welt öffnet sich – 5G

Gerhard P. Fettweis – Vodafone Stiftungsprofessur – TU Dresden

vodafone chair @ TU Dresden: Key Facts & Figures

The Team

1	Professor
8	Senior scientists/lecturers
3	Post-docs
40	Ph.D. students
15+	Master students
3	Program managers
12	Start-up incubator employees
2	Secretaries
7	Lab engineers

IPP Sponsors

amdocs, ALTERA, KATHREIN, BOSCH, HUAWEI, ARM, intel, NATIONAL INSTRUMENTS, NOKIA, cadence, ROHDE&SCHWARZ, synopsys, XILINX

vodafone
TECHNISCHE UNIVERSITÄT DRESDEN

Accomplishments

Scientific:

- 83 Ph.D. grads
- 270+ Ms. grads
- 900+ publications
- 17,500+ citations
- 200+ patent appl.
- 85+ patent families

Innovation:

- 16 spin-outs
- 300 engineers

Funding:

- € 60M Chair
- € 60M VC
- € 1/2B projects

Project Partners

vodafone, NOKIA, CLAAS, NATIONAL INSTRUMENTS, SAMSUNG, DFKI Deutsches Forschungszentrum für Künstliche Intelligenz GmbH, ERICSSON, IDT, NEC, GWT forschung+innovation, ihp, cea, leti, Masdar Institute, HORIZON 2020, 5G PPP, Deutsche Forschungsgemeinschaft DFG, Bundesministerium für Bildung und Forschung, Europa fördert Sachsen. ESF Europäischer Sozialfonds, Freistaat Sachsen Staatsministerium für Wissenschaft und Kunst

The Vodafone Chair's Startup History

1999 OnDSP™ based WLAN chip-sets
systemonic — 2002 → NXP founded by Philips

2000 SON systems
radioplan — 2006 → amdocs

2003 Broadband Wireless HW (LTE,…)
SIGNALION — 2012 → NATIONAL INSTRUMENTS

2004 Module and reference board design
IN-CIRCUIT — 2006 → IN-CIRCUIT

2005 MPSoC semiconductor IP
DRESDEN SILICON — 2007 → SIGNALION

2007 Wireless audio
freedelity

2008 Network performance measurement
RADIOOPT — 2016 → vodafone

2008 LTE Cellular Handset Chip IP
blue wonder communications — 2012 → intel

2010 Satellite Communications
INRADIOS integrated radio solutions — 2017 → ROHDE & SCHWARZ

2012 Startup incubation and growth partner
HighTech Startbahn
STARTBAHN Venture Fonds

2013 Assisted living & IoT
exelonix

2013 Bitcoin harvesting engines
CB COINBAU.com

2013 Massive MIMO Cells
AIRRAYS

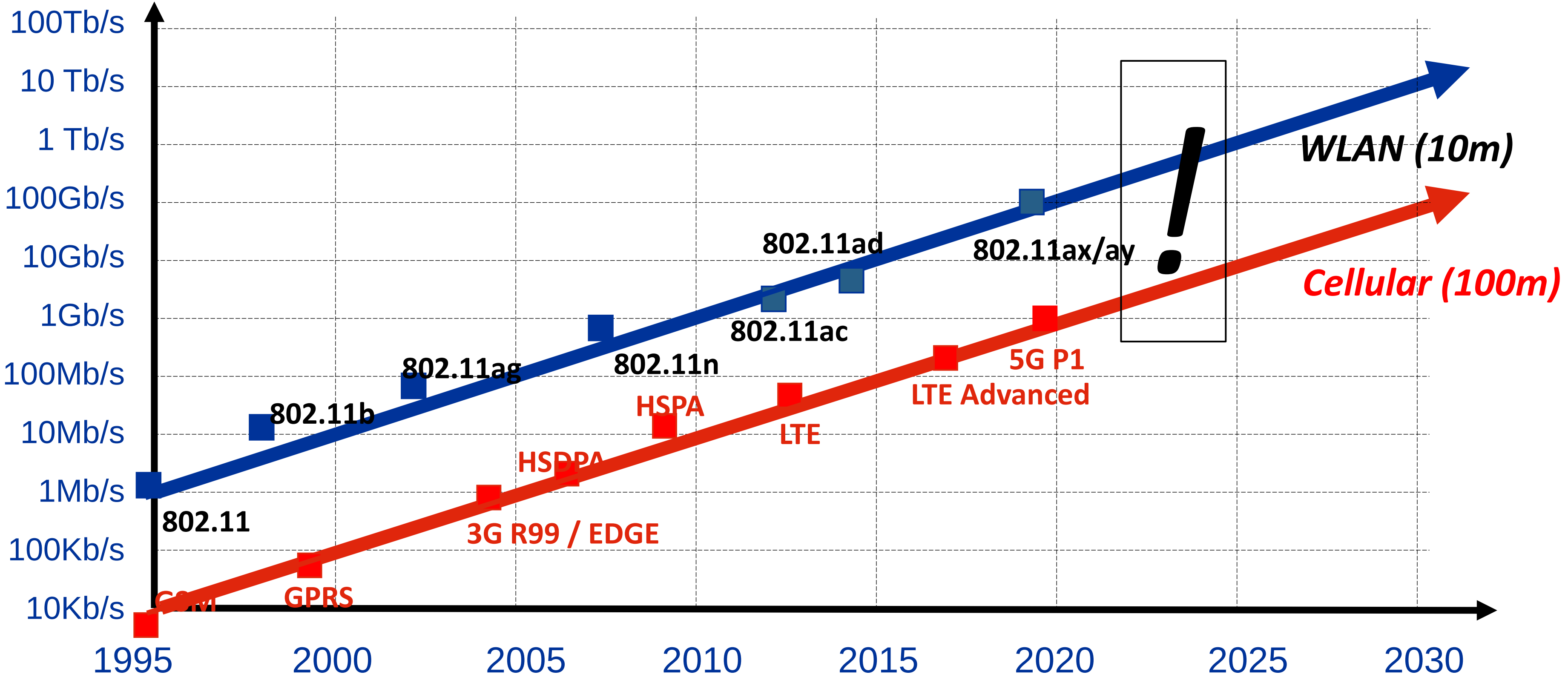
2014 Machine vision for manufacturing
VISINAUT

2015 Cellular IoT Chip IP
CommSOLID

2016 Telemetry for IoT
metirionic WIRELESS DISTANCE MEASUREMENT

The Wireless Roadmap


The Wireless Roadmap >2020 Outlook



Große Zellen?

Abdeckung in ländlichen Raum

Datenrate – Wie geht das?

10 kb/s empfangen ➔ Empfangsleistung muss größer Rauschleistung sein

„SNR“ (signal-to-noise-ratio)

GSM: typ. 10km Zellradius

100kb/s empfangen ➔ 10x Empfangsleistung notwendig?!

10kb/s → 1Gb/s heißt 100‘000x Sendeleistung erhöhen?

Erstes Lösungsansatz

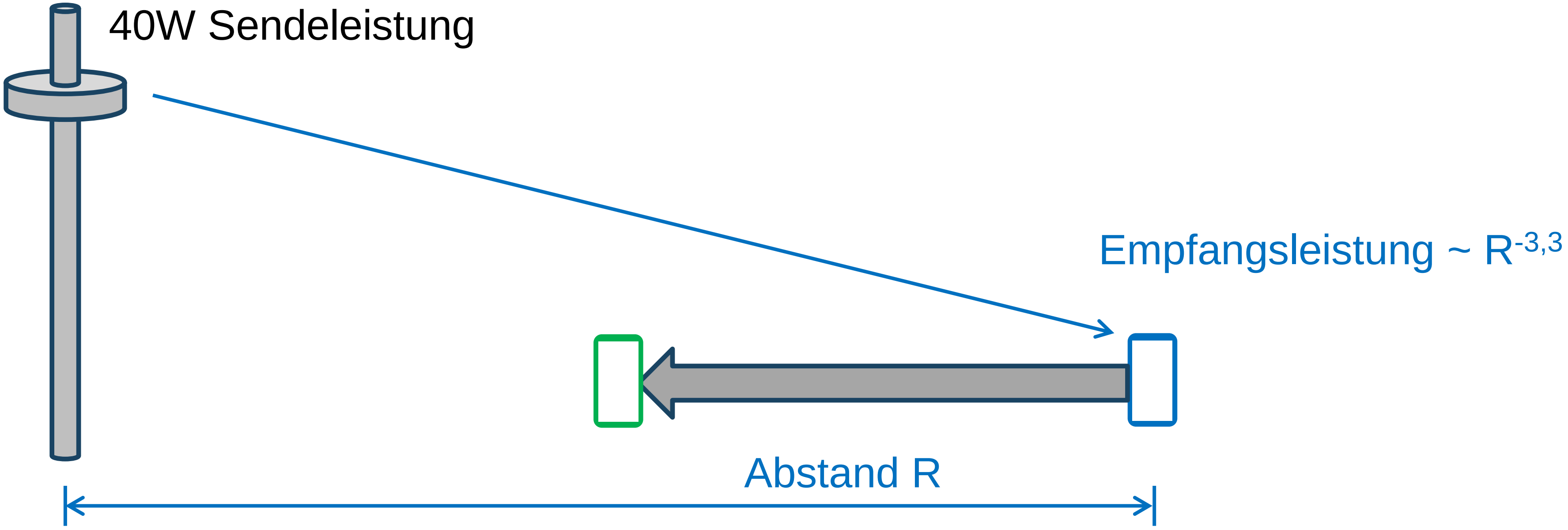
Verbesserte Signalverarbeitung

Analog „Headset mit Rauschunterdrückung“

→ **10x**

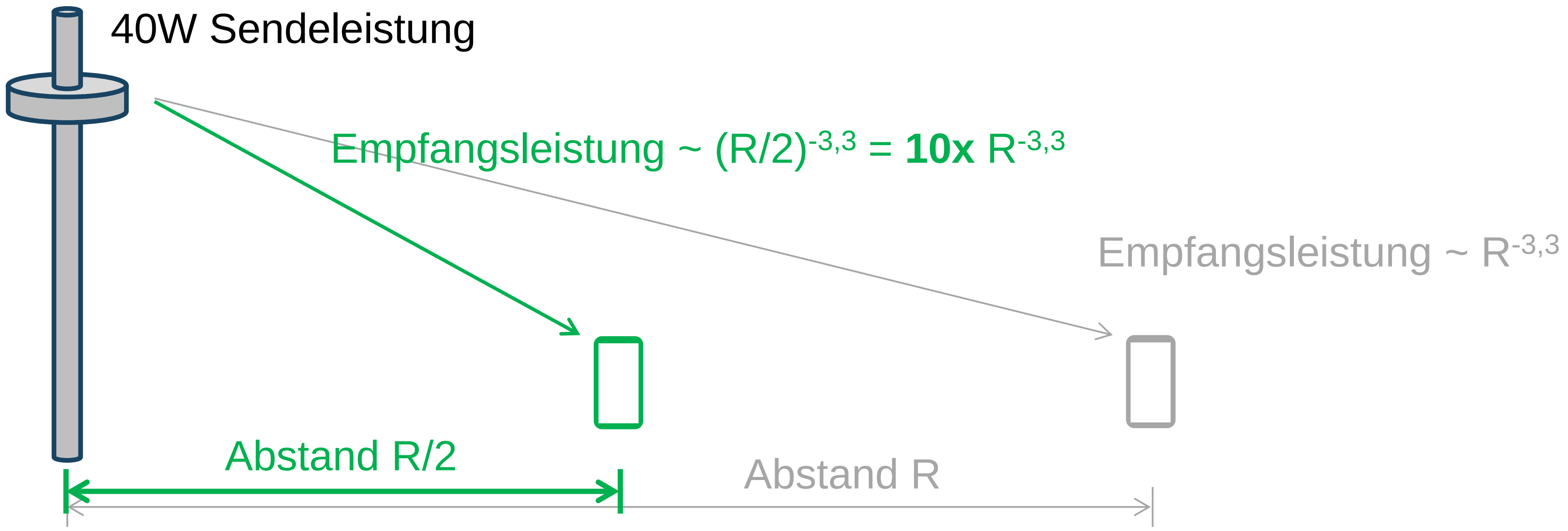
Zweiter Lösungsansatz

Zellverdichtung

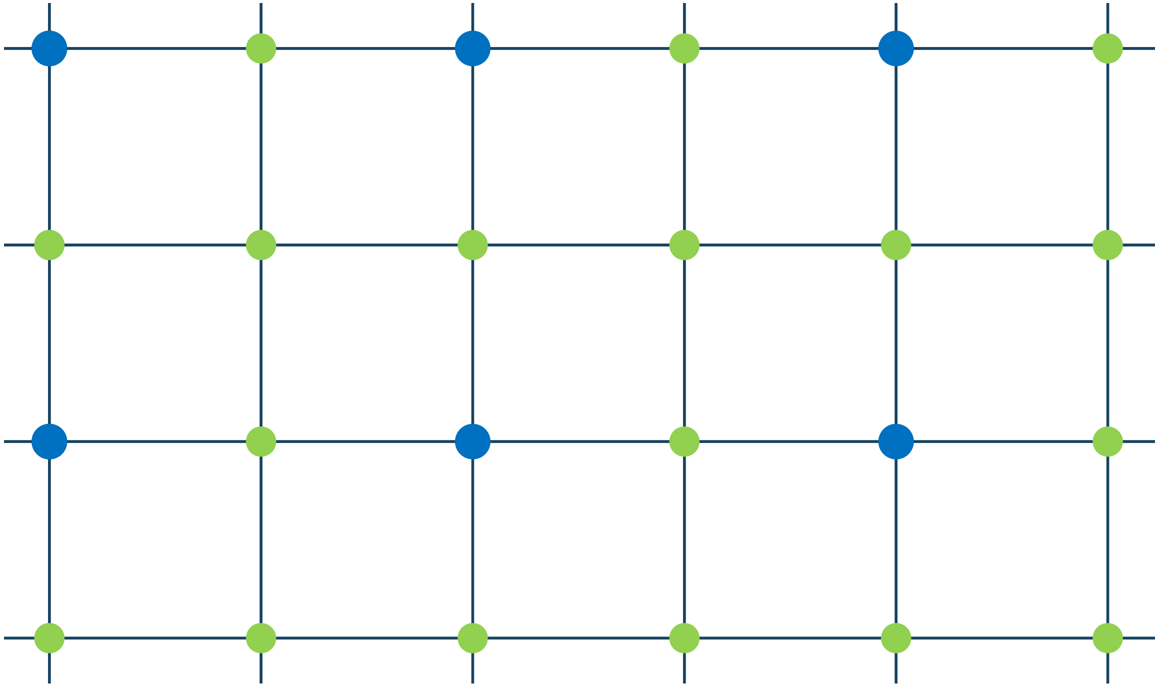


Zweiter Lösungsansatz

Zellverdichtung



Beispiel – Halber Abstand in der Fläche



4x Verdichtung Basisstationen

Fazit Zellverdichtung

Städtisch ~ $R^{-3,3}$

Ländlich ~ $R^{-2,5}$

Städtisch 10x Datenrate ➔ 4x Zellverdichtung

Ländlich 10x Datenrate ➔ 6x Zellverdichtung

Fazit: Glasfaserausbau vorantreiben *!*

Fragestellung Datenrate: nicht für dünn besiedeltes Gebiet *?!*

Dritter Ansatz

Funkfrequenz

500MHz versus 2,5GHz ➔ Reichweite „10x“

Leider – aufgrund terrestrischem TV sind beste Frequenzen vergeben

5G Frequenz bei 3,5GHz…???

Besser – Mobilfunkvergabe von UHF Fernsehband unter 1GHz

Vierter Ansatz

Höhe der Basisstationsantenne

10m → 100m ➔ 10x (und mehr)

NEU: Fünfter Ansatz

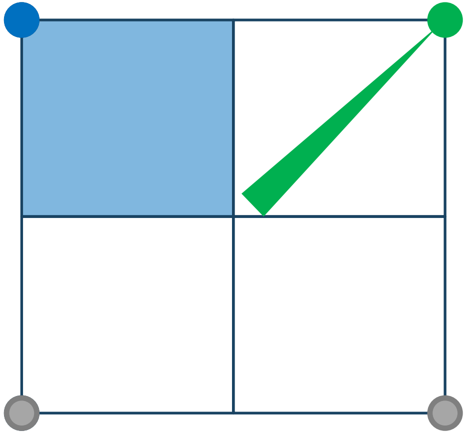
Antennengewinn („massive MIMO“)

Flächig angeordnete Antennenelemente

Beim Senden: Weniger „ausleuchten“ mit selber Sendeleitung

Beim Empfang: „Besser gerichtet zuhören“

➔ 100x



Zusammenfassung: 100‘000x Datenrate

1Gb/s pro Nutzer an Basisstation: Glasfaseranbindung *!!!*

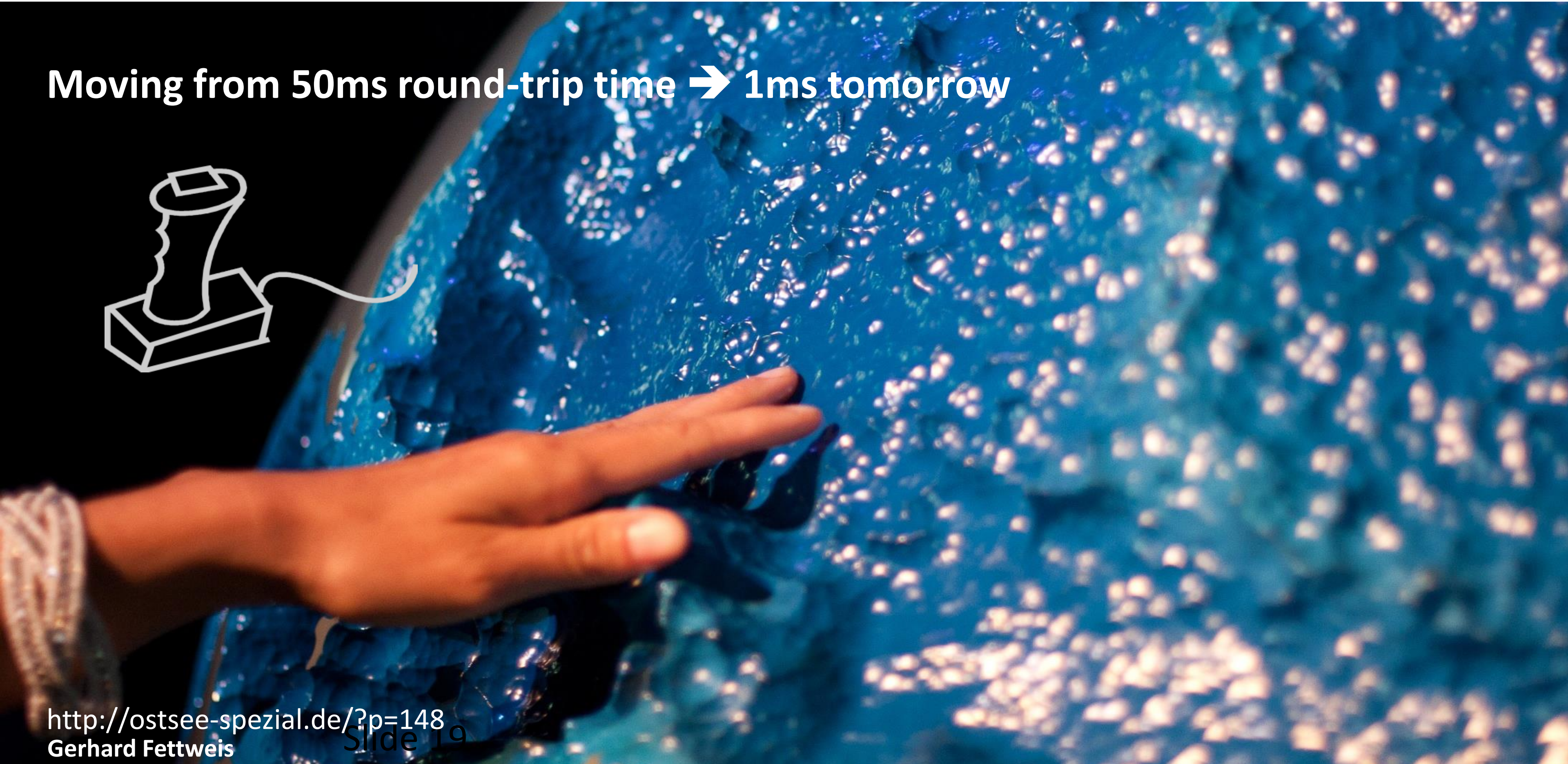
100‘000x Datenrate

Signalverarbeitung:	ca. 10x	
Masthöhe	ca. 10x	
Zellverdichtung	1000x ?	Ländlich 6x6x6x = ca. 200x
		Städtisch 4x4x4x = ca. 60x
massiveMIMO:	ca. 10x bis zum Jahr 2020, (100x erst 2025)	

5G

Das ***Taktile Internet*** beginnt

The Tactile Internet



Moving from 50ms round-trip time → 1ms tomorrow

http://ostsee-spezial.de/?p=148

Gaming: They were the first to recognize …

Revolution Ahead: The Tactile Internet

5G:

Ubiquitous

Steering & Control Communications

Health & Care
Traffic & Mobility
Sports & Gym
Edutainment
Manufacturing
Smart Grid
…

≤ 4G:

Ubiquitous

Content Communications

IoT

Internet of Things

…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GERMANY


© Prof. Gerd Hirzinger

Industrial

The Tactile Internet
The Manufacturing Revolution Ahead

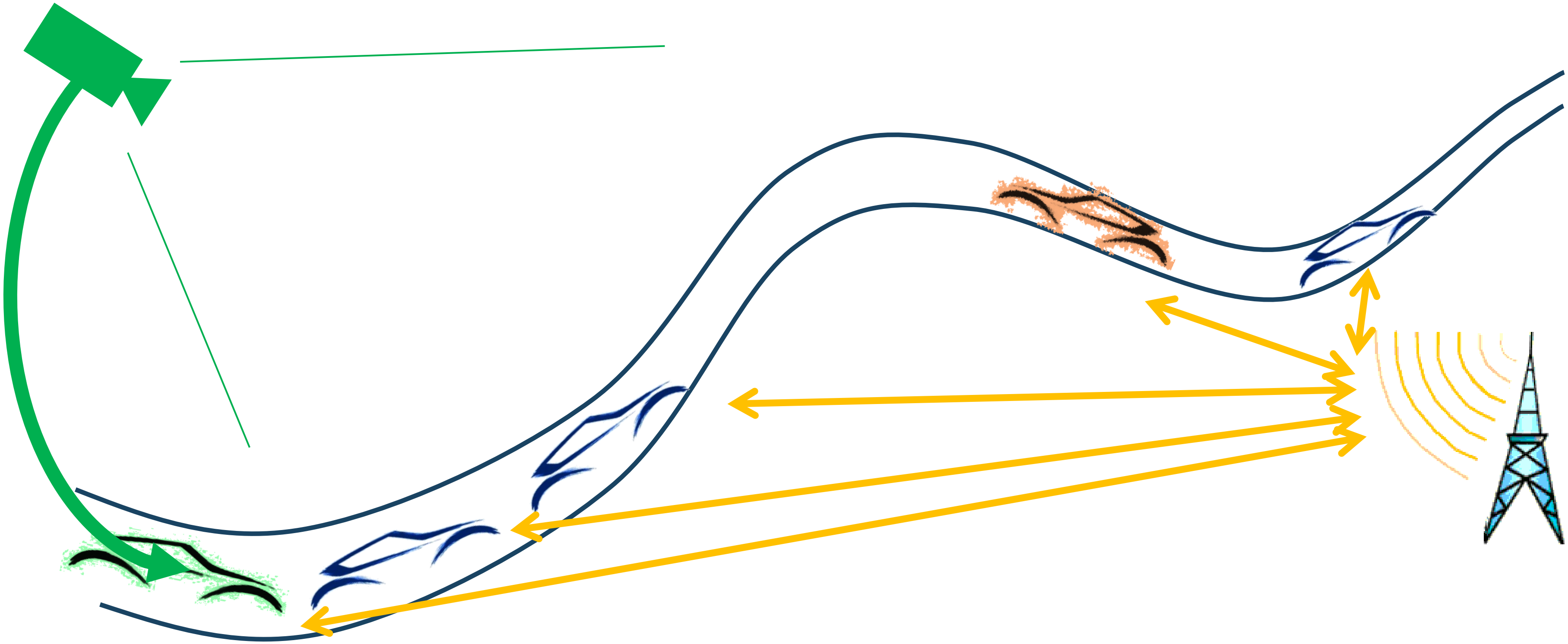

http://www.actemium.com/wp-content/uploads/2016/05/robotics.jpg


http://www.witchdoctor.co.nz/wp-content/uploads/2013/01/robot-fabrication-station.jpg

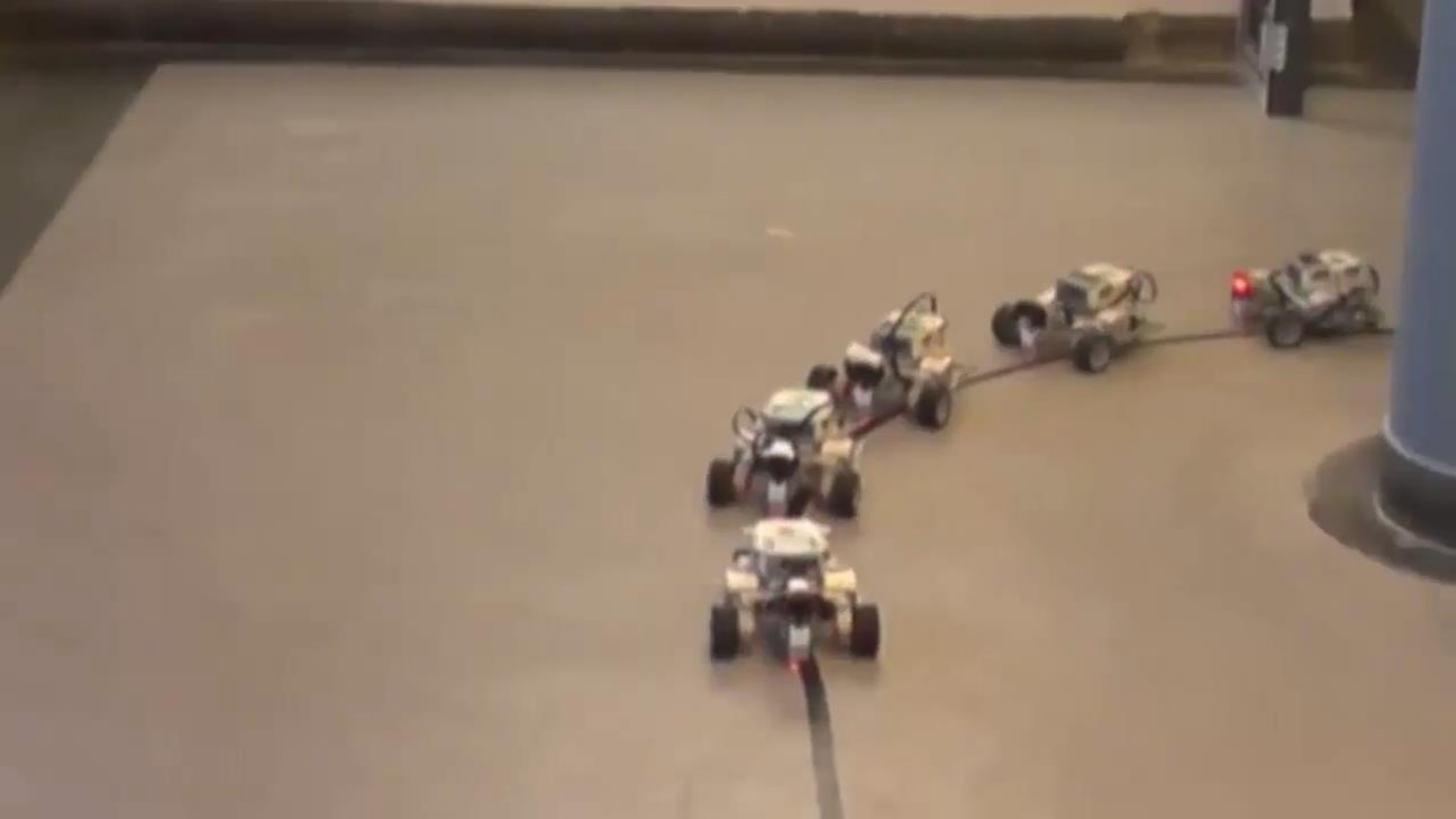
Design Service: A Job Machine

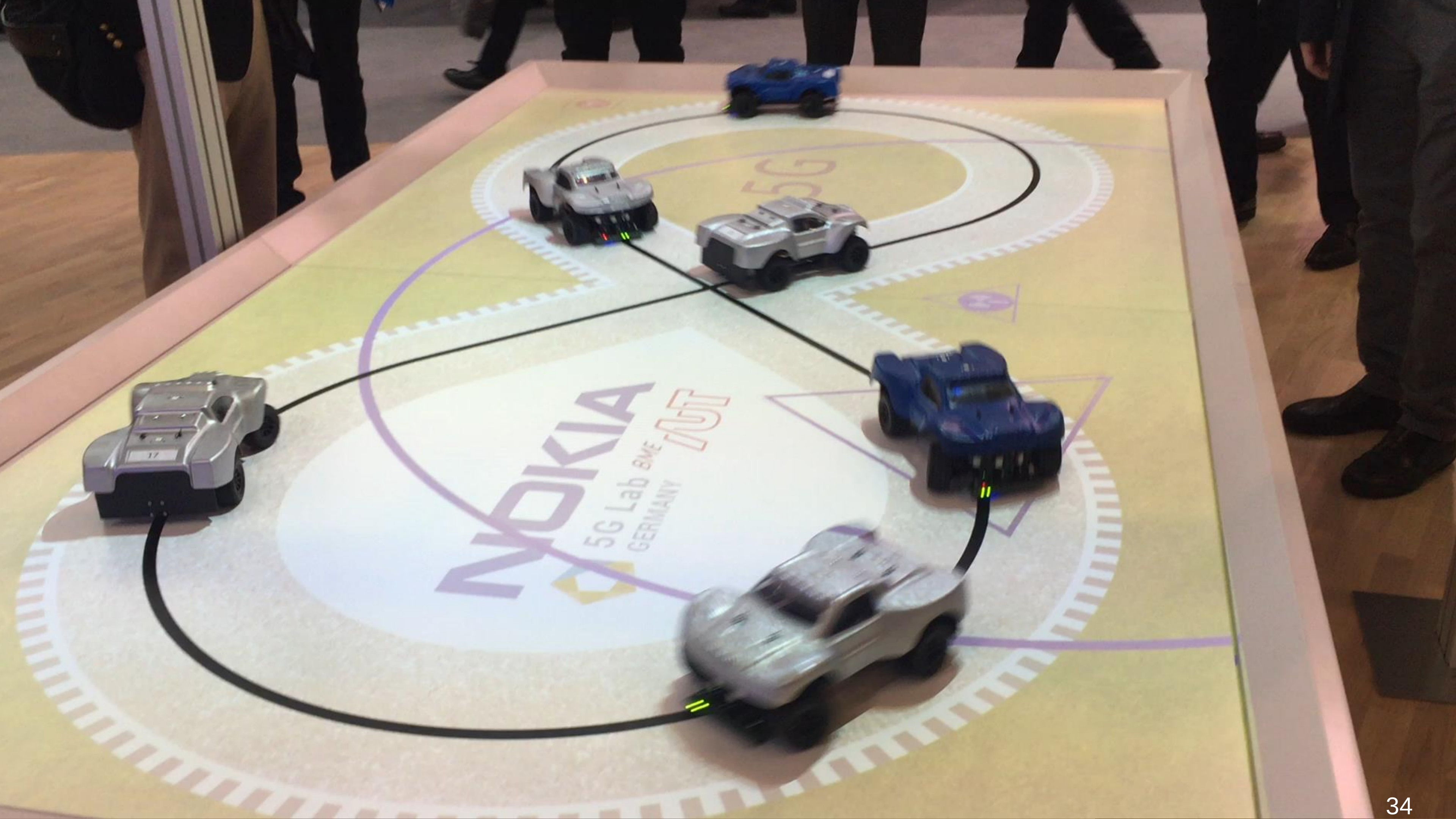
Automotive

Heads-Up With Rendered Bird's Eye Look-Ahead



ESC / No ESC – The Millisecond Game Changer

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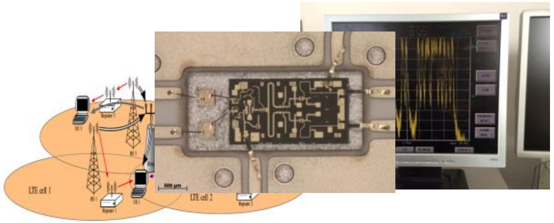
Precision Farming

CLAAS 5G Project

The Future Precision Farming Machine

Conclusions

5G Research on Four Tracks



Wireless

Tactile Internet Applications

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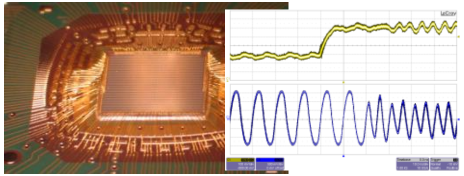

Hardware

Network & Edge Cloud

Members on Tracks

Hardware Track

Dirk Plettemeier


Frank Ellinger


Karlheinz Bock


Christian Mayr


Michael Schröter


Kambiz Jamshidi


Wireless track

Gerhard Fettweis


Frank Fitzek


Eduard Jorswieck


Thorsten Strufe


Silvia Santini


Edge Cloud & Networks Track

Wolfgang Nagel


Christof Fetzer


Wolfgang Lehner


Hermann Härtig


Christel Baier


Tactile Internet Application Track

Ercan Altinsoy


Uwe Aßmann


Peter Birkholz


Leon Urbas


Klaus Janschek


Thomas Herlitzius


Team of 600+ Researchers !!!

Cellular Killer Apps

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5G – 2022
+ Tactile Internet

4G – 2012
+ Data works!
+ Video works!

"Gaming"
"3D graphics"

3G – 2002
+ Data
+ Positioning

"Video phone"

2G – 1992
Voice
Messages

"Car phone"

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¥€$

£ots of Opportunities of 5G Ahead

Starting Now !!!

Thank you Vodafone for 23 years of continued support !

www.vodafone-chair.com

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Selected References

more to be found at www.Vodafone-chair.com

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