

PHOTONIC TECHNOLOGIES IN FUTURE CAMPUS NETWORKS

Ronald Freund, Fraunhofer Heinrich Hertz Institute, Berlin, Germany



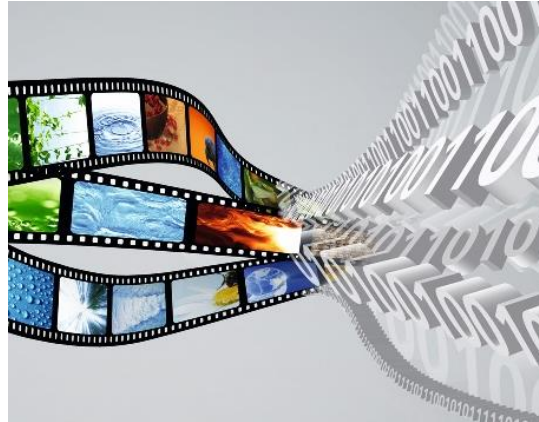
AGENDA

- Introduction
- Fifth Generation Fixed Networks (F5G)
- Photonic Technologies for Campus Networks
- Summary

Fraunhofer Heinrich Hertz Institute (HHI), Berlin, Germany



$10^0 - 10^2 - 10^4$ Tbps



H.264 – H.265 – H.266



3G – 4G – 5G – 6G

- Research: Photonic Networks / Systems / Components, Wireless and Video Coding
- Every second bit on the internet touches Photonic or Video Technology invented or made by Fraunhofer HHI

Open Testbed Facility for Edge / AI-based Industry 4.0

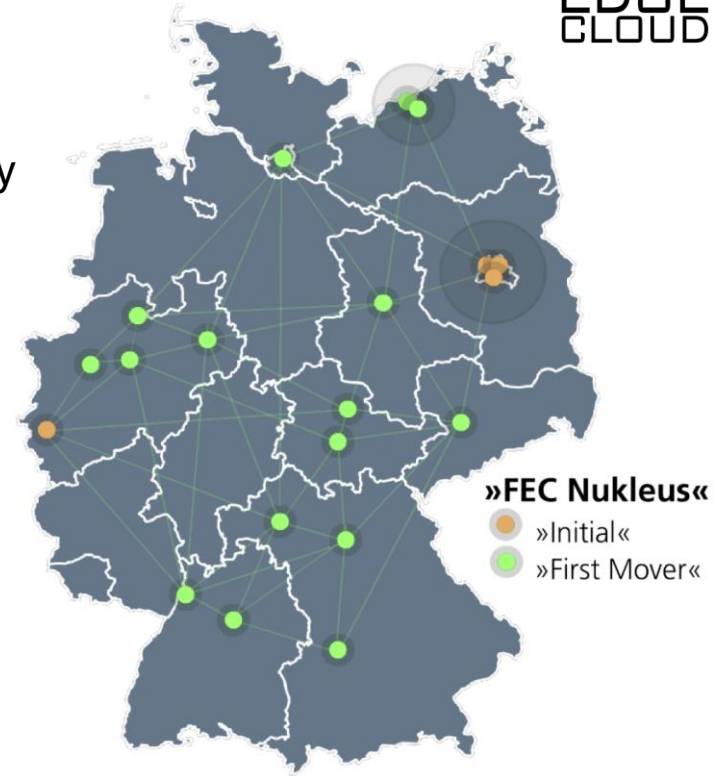
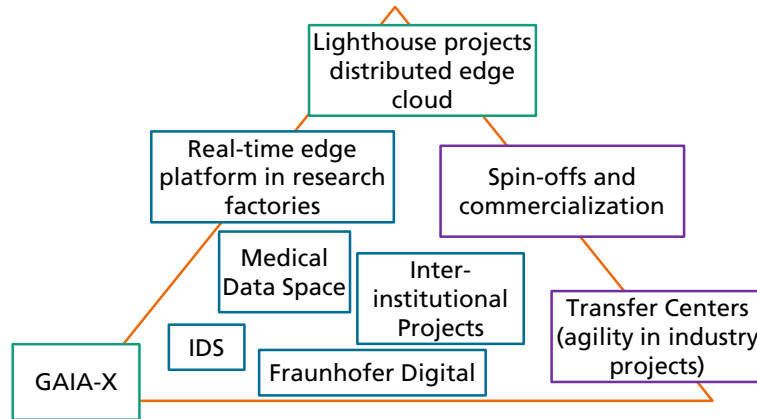
Activity of several Fraunhofer Institutes and Partners

- Comprehensive testbed for industrial edge cloud applications
- Test of **photonic technologies**
 - Passive Optical Networks (PONs)
 - LiFi / LiDAR
 - Quantum Key Distribution (QKD)
- Blueprint for other fields of application (e.g. public safety, medical, etc.)



Fraunhofer Edge Cloud (FEC)

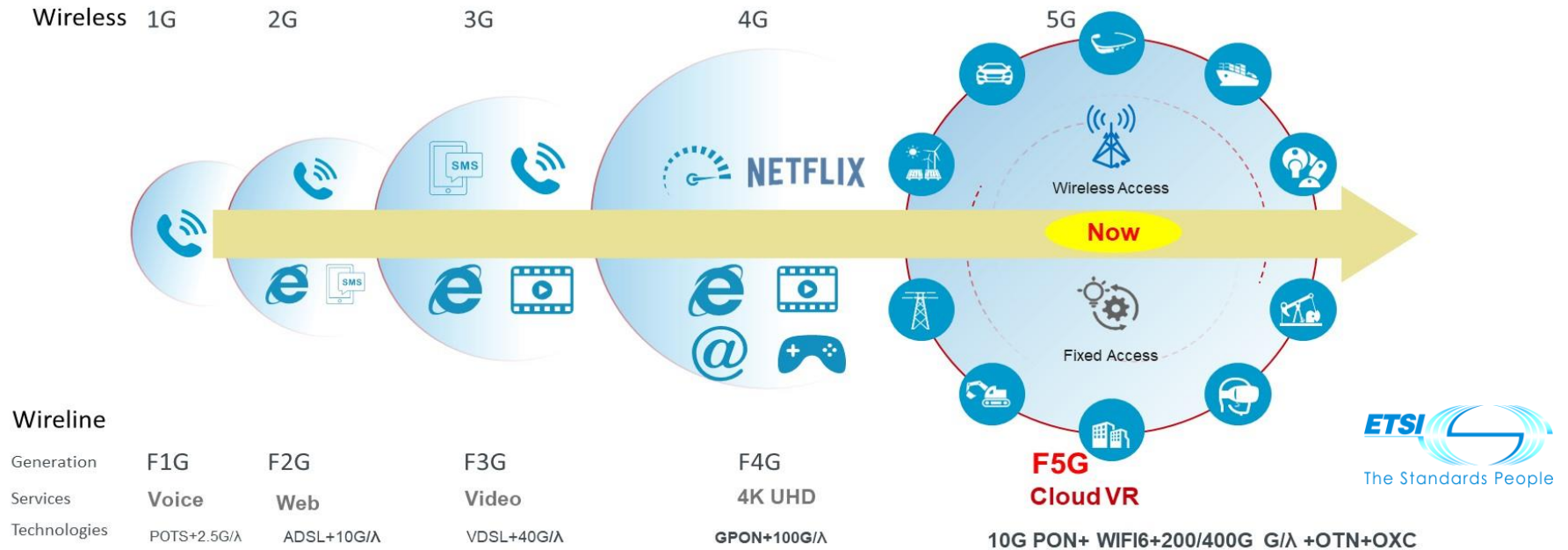
- Innovative, real-time-capable cloud infrastructure
- FEC as a real-life laboratory for politics and industry
- Platform for cross-institutional projects
- Pilots: HHI (Berlin) and IPT (Aachen)



AGENDA

- Introduction
- Fifth Generation Fixed Networks (F5G)
- Photonic Technologies for Campus Networks
- Summary

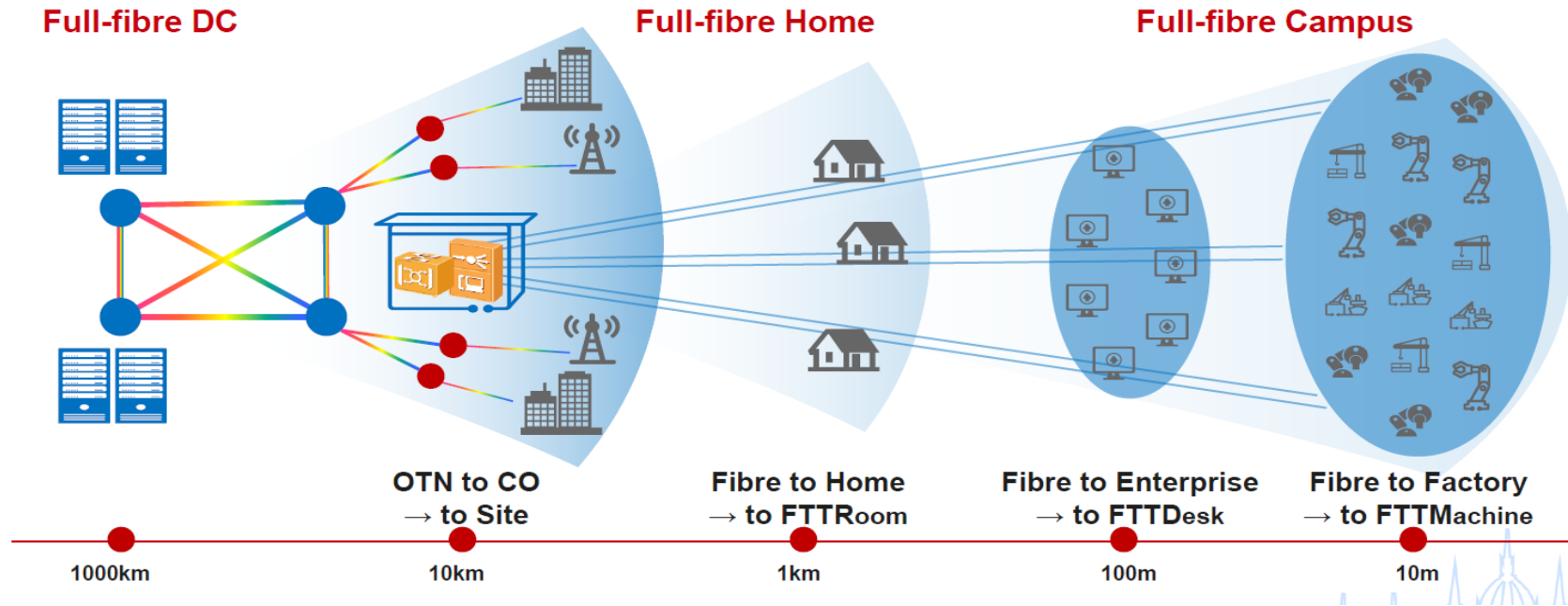
Evolution of Fixed Network: from F1G to F5G



<https://www.etsi.org/technologies/fifth-generation-fixed-network-f5g>

F5G: Fifth Generation Fixed Networks

Build Ubiquitous Full Fibre Connectivity

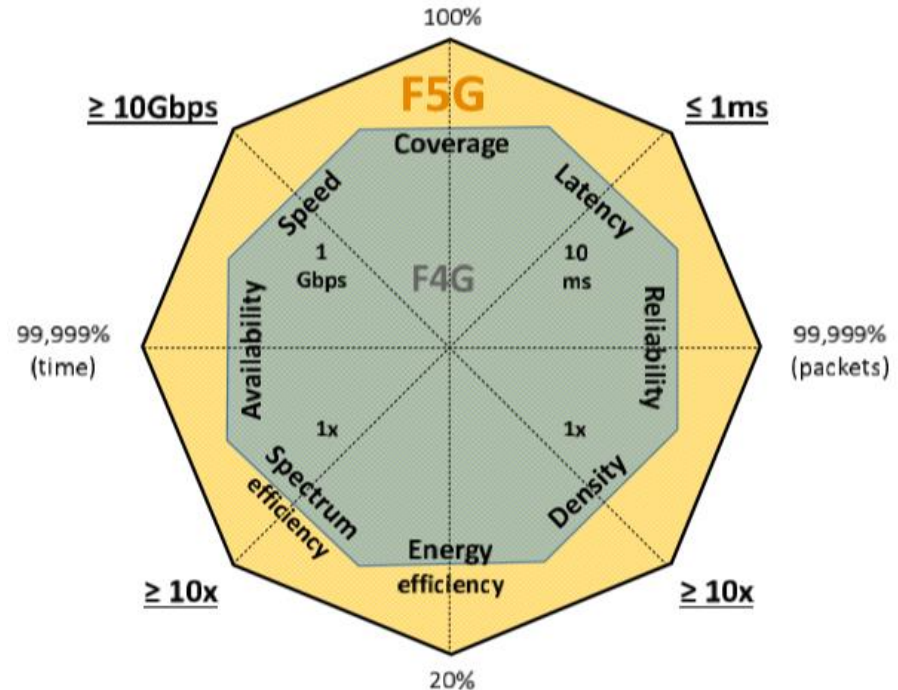


<https://www.etsi.org/technologies/fifth-generation-fixed-network-f5g>

Ambition of F5G - Fiber to Everything, Enabling All Industries

Gaps and Challenges for F5G

- Extending to more end-user:
2Home, 2Room, 2Business,
2Machine, etc.
- Reducing everywhere the fibre-to-end-user distance: km → 100m → 10m → 1m
- Number of connections expanding:
x3 (room), x10 (desk), x30 (machine), x100 (smart city)
- 10G PON: 10 Gbps symmetrical, 100 μs latency -> 50G to 100G PON
- 200/400G -> 800G (per lambda)



https://www.etsi.org/deliver/etsi_gr/F5G/001_099/001/01.01.01_60/gr_F5G001v010101p.pdf

The Vision of F5G: Autonomous Converged Networks



Smart city



Smart industry



Smart government



Smart xxx...

“Zero X” Experience

- ✓ Make the simplicity to the users
- ✓ Leave the complexity with the providers

As a Service

- ✓ One stop, real-time, on demand, automated, E2E full lifecycle network/ICT services

Zero Wait

Swift

- Launch
- Delivery
- Care

Autonomous

Zero Touch

Simplified

- Operating
- Development
- Maintenance

Agile

Zero Trouble

Self-healing

- Business
- Services
- Infrastructure

All-inclusive



As a Platform

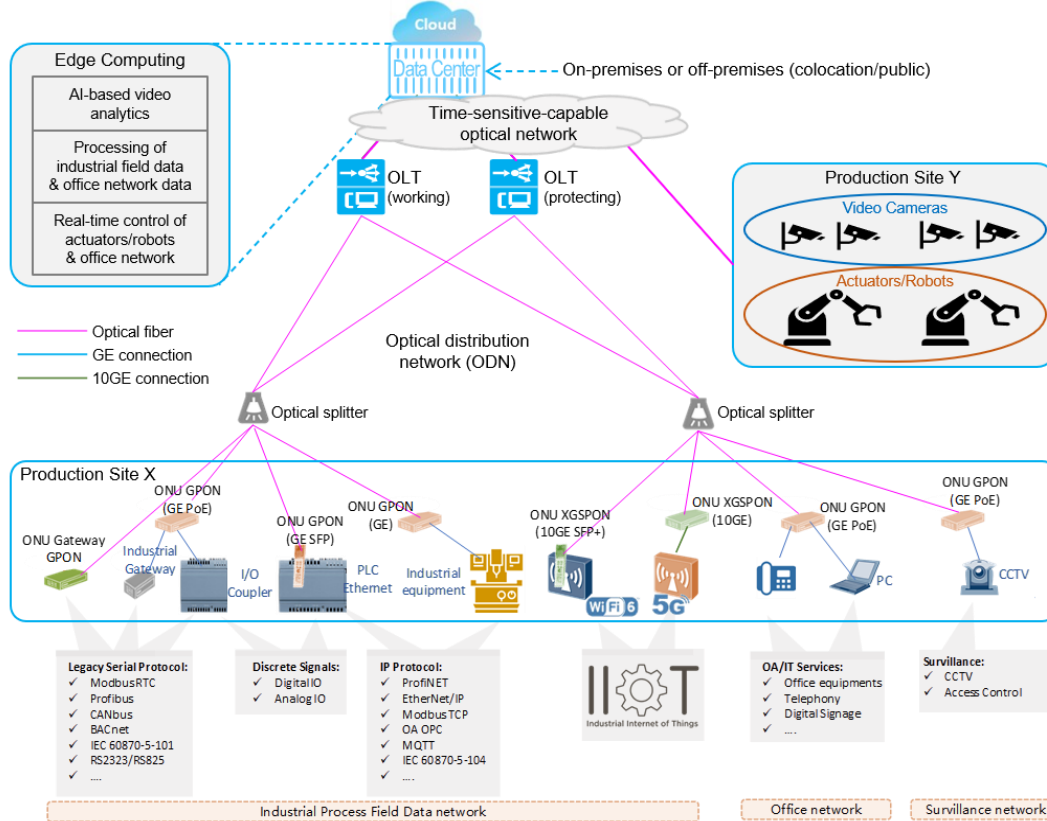
- ✓ Enablement of business collaboration & ecosystem between verticals and network/ICT service providers

<https://www.etsi.org/technologies/fifth-generation-fixed-network-f5g>

AGENDA

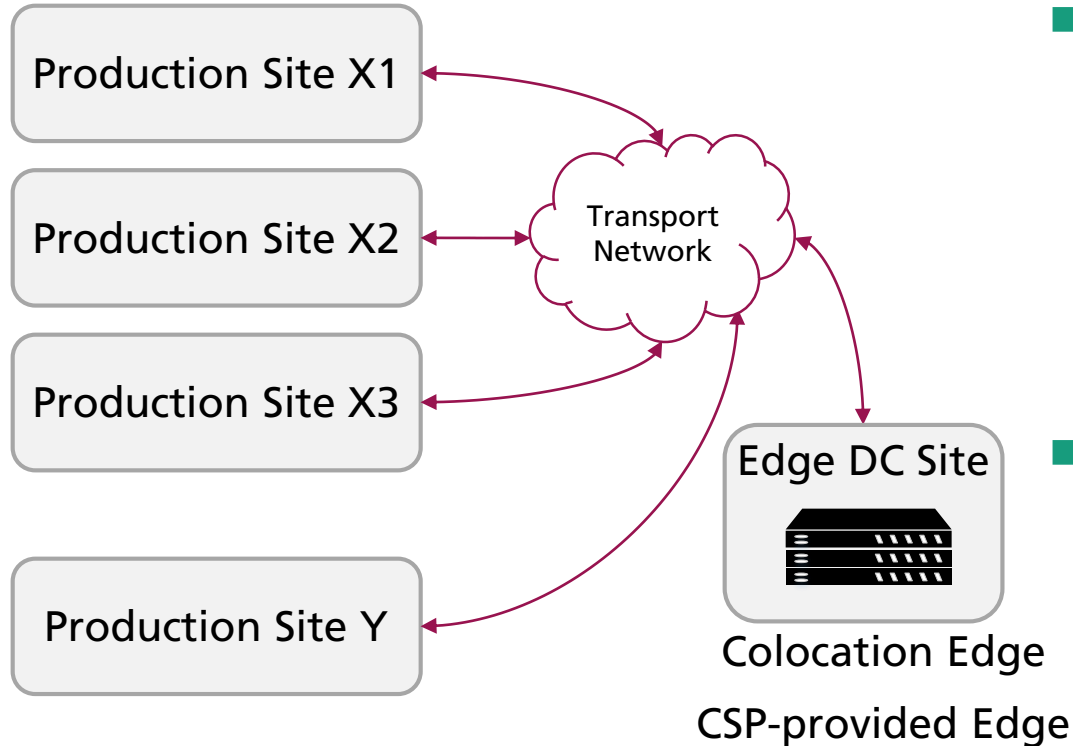
- Introduction
- Fifth Generation Fixed Networks (F5G)
- Photonic Technologies for Campus Networks
- Summary

Network for Cloud-based Industrial Applications



Source: L. Pesando, et al., "Service-Enabling Architecture and Application of the 5th Generation Fixed Network (F5G)," submitted to IEEE Communication Magazine, June 2021.

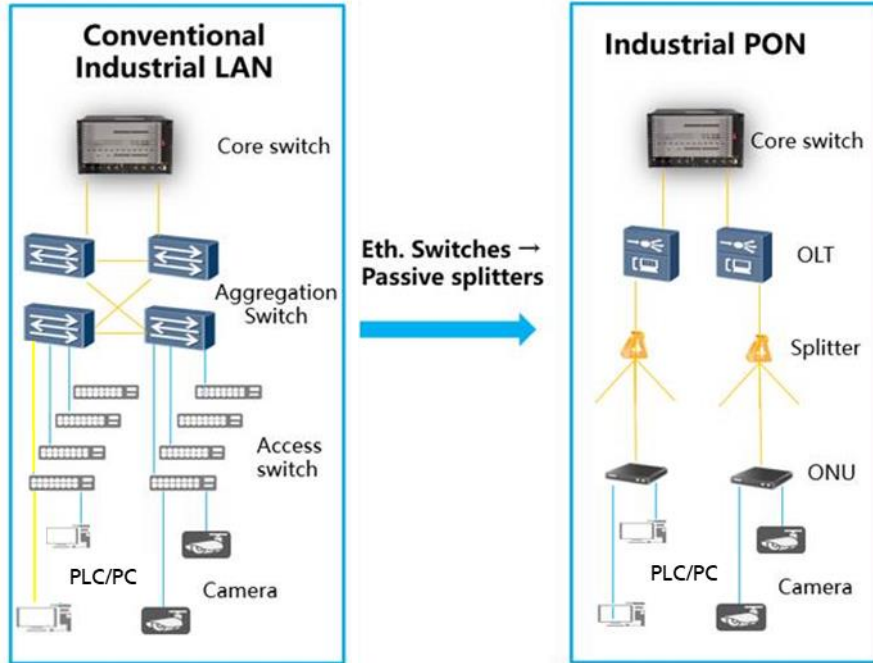
Edge Clouds for Industrial Applications



- **Off-Premise Private / Public Edge Cloud** connected via a real-time communication network offers new, economically highly attractive possibilities, especially for small and medium-sized manufacturing companies.
- For real-time support of distributed, urban production sites, **a real-time, low-latency, broadband fibre optic infrastructure is required!**

Key Technology I: Passive Optical Network (PON)

For Cost/Energy efficient Campus Networks



PLC: Programmable Logic Controller

OLT: Optical Line Terminal, ODN: Optical Distribution Network ONU: Optical Network Unit

	Ethernet LAN	PON
Bandwidth	100M - 1/10G	2.5G - 10G - 50G
Reach	100 m	20 km
Power Consumption	high	low (passive splitter)
Maintenance	yes	no
Upgrade	all switches	ODN stays unchanged
Costs	high	Low

Key Technology II: LiFi (optical wireless) Communication

Advantages, Use Cases, CE certified Hardware

- Additional unregulated (huge) spectrum for high capacity and enhanced security
- No interference with radio allows for joint and dense deployments
- Indoor use cases: industrial, conference and class rooms, hospitals, aircraft, ...
- Outdoor use cases: connected streetlights, smart city, backhaul, car-2-car, ...

Office LiFi (USB)



Industrial LiFi (50 m²)



Outdoor LiFi (100 m)

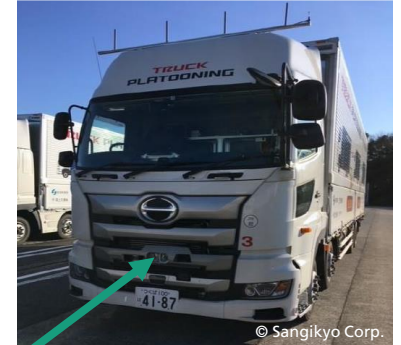


Vehicle to Vehicle Communication with LiFi

Truck-to-Truck Platooning with Sangikyo Corp.

- Use of directed LiFi links for platooning, mounted at truck bumpers
 - Manual driving truck is followed by autonomous trucks
 - ~ 10 m distance between trucks at 80 km/h speed
 - Real life demonstration at Tomei Highway, Japan

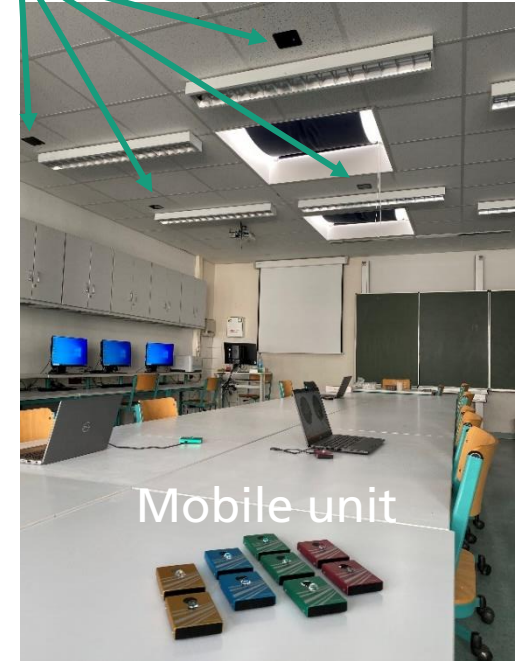
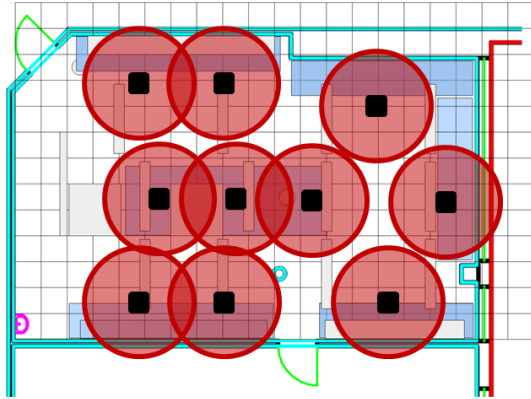
LiFi Link



First Networked LiFi Installation in D

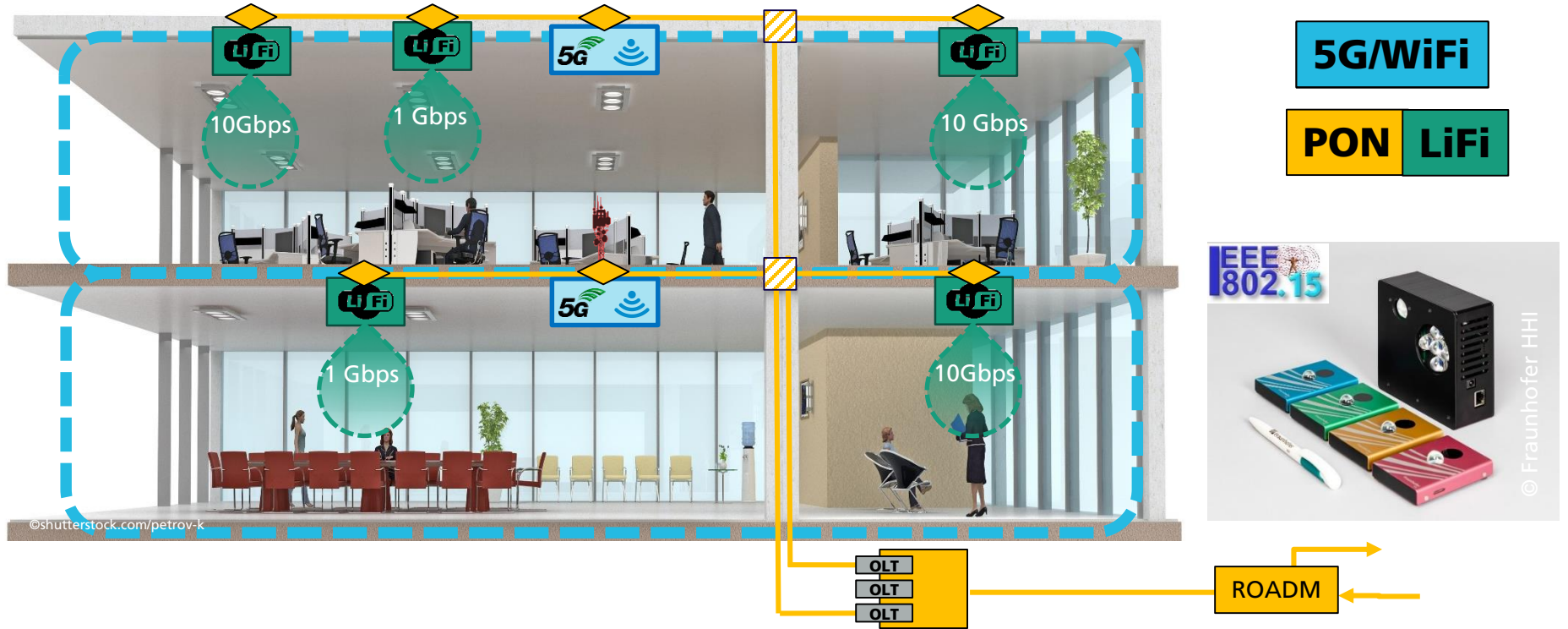
Residential LiFi

- Networked LiFi installation in a classroom
 - Main-Kinzig-Kreis, Hessen, Germany
- Central unit connects up to 8 LiFi APs
- Seamless mobility, 500 Mbit/s downlink



LiFi-enhanced Campus Networks: Office Use Case

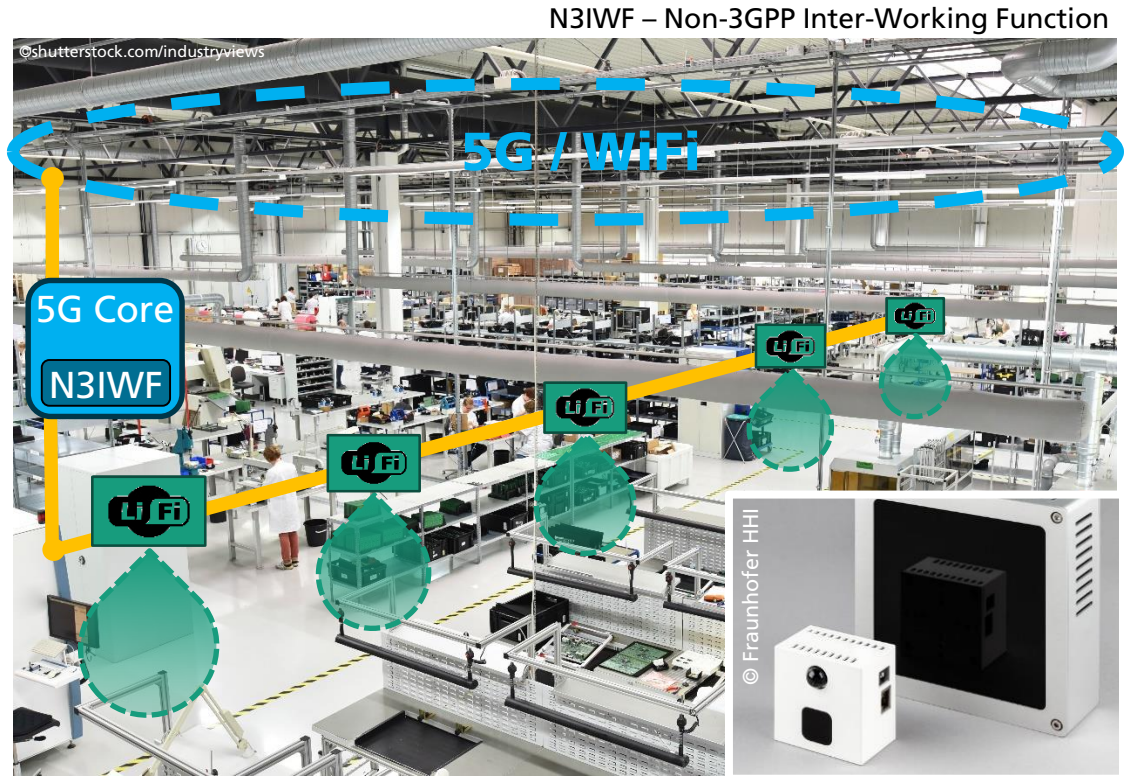
Indoor Coverage with 5G | WiFi6/7 | LiFi2



LiFi-enhanced Campus Networks: Industrial Use Case

LiFi in Production Environments

- LiFi-enhanced 5G for industry
 - Smart factories, IIoT
 - Higher area capacity for larger number of devices
 - Integrated positioning
 - Robust against EMI
- Horizontal handover
 - LiFi = extra antenna in WiFi
 - 5G core support of LiFi+WiFi



AGENDA

- Introduction
- Fifth Generation Fixed Networks (F5G)
- LiFi-enhanced 5G Campus Networks
- Summary

Summary

- Networks are experiencing an explosion of new services with new needs, e.g., for high bandwidth, low latency, edge computing capability, security ...
- Passive optical networks are attractive to build cost efficient campus networks
- 5th generation fixed networks will make it easier to:
 - Leverage the potentials of AI and edge computing
 - Integrate and control new system technologies, such as LiFi
- LiFi is a mature wireless technology providing the following advantages:
 - Additional unregulated spectrum with high capacity (per area)
 - No interference with radio allows for joint and dense deployments
 - Enhanced security

Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute, HHI

**WE PUT SCIENCE
INTO ACTION.**

Contact:

Prof. Dr. Ronald Freund, MBA
ronald.freund@hhi.fraunhofer.de
+49 (0)30 31002-652 / +49 173 5847479

Einsteinufer 37
10587 Berlin

www.hhi.fraunhofer.de/pn

