5G Alliance for Connected Industries and Automation

Millimeter-Wave Spectrum for Industrial 5G - Potentials and Challenges

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Relevance of mmW spectrum from an industrial end user's perspective

Advantages of 5G mmW spectrum

- Access to licensed spectrum with higher bandwidths than in Sub6 (e.g., up to 800 MHz in Germany)
  - Potentially higher data rates, lower latencies
- Easier interference management (i.e., with adjacent spectrum, with adjacent NPNs)
  - easier radio planning, no need to take care about neighbor NPNs
  - flexibility on setting non-standard TDD patterns (downlink-heavy, uplink heavy

Drawbacks of 5G mmW spectrum

- Propagation physics with higher attenuation than for Sub6 spectrum
- Lack of available industrial 5G devices
- Robustness of mmW in industrial context unclear

13 countries have decided to grant mmW NPN spectrum, 6 are in discussion

(15 have decided to grant sub-6 spectrum)

Availability of mmW spectrum for NPN (courtesy of 5G-ACIA)

Potential use cases for 5G mmW

Requirements for industrial applications with high bandwidth demands

Uplink-heavy use cases

- Machine vision
  - Quality inspection with high resolution and high framerate
  - Pick & Place
  - Cameras with GigE, 5 GigE, and 10 GigE interfaces are common
  - 3D imaging with TOF, Stereovision, or Time-of-Flight (TOF)
  - Triggering and synchronization with low latency & jitter is often needed
- Video capture, drone- or AMR-based inspection

Downlink-heavy use cases

- Automotive production
  - Download of software and firmware of ECUs and multimedia systems
  - Download and flashing for multiple cars in contiuous flow production (multiple GB per car)

For 5G mmW, subcarrier spacing can be increased, which may decrease the slot size – in theory!

5G-ACIA endorsed testbed

»5G mmWave for industrial applications with high bandwidth demands (T011)«

- 6 testbed members (100% 5G-ACIA members)
- testbed lifetime May 2023 - Sept 2025

Fraunhofer IPT *
- testbed main contact
- use cases
- measurements

ERICSSON *
- infrastructure
- measurements

Qualcomm *
- devices
- measurements

BASLER
- use cases

VOLKSWAGEN AKTIENGESELLSCHAFT
- use cases

ROHDE&SCHWARZ Make ideas real
- measurements

* = Testbed activities part of EU project TARGET-X

TARGET-X

Co-funded by the European Union

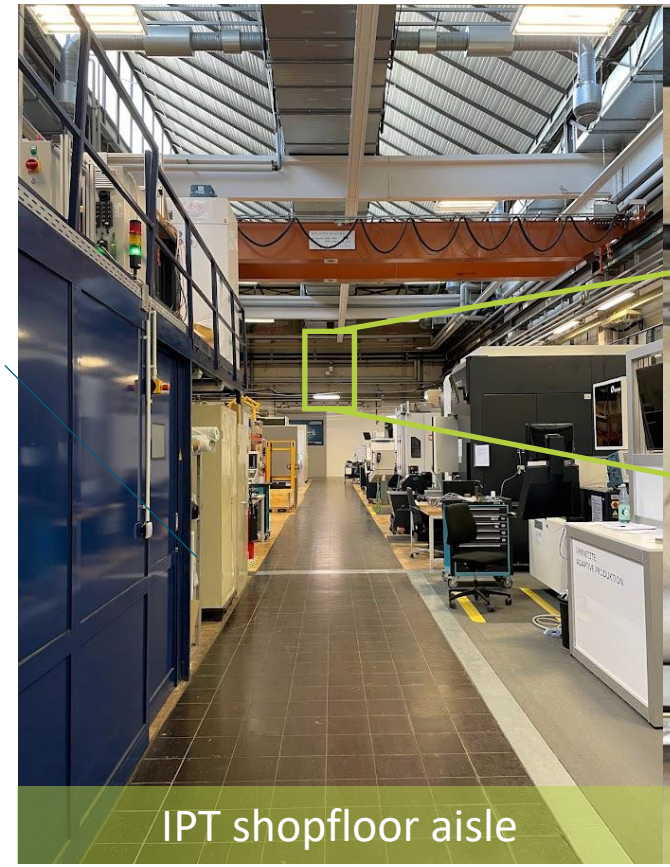
6GSNS

- Testbed located at the 5G-Industry Campus Europe
- 5G-NSA/SA network
  - Radio and Core Network supporting LTE and NR
- Spectrum
  - FR2: 26.7-27.5 GHz (TDD / n258)
  - FR1: 3.7 – 3.8 GHz (TDD / n78)
  - LTE anchor bands: 2.51 GHz UL/ 2.63 DL (FDD / B7), 2.0-2.32 GHz (TDD / B40)
- Facility
  - 2.700 m² shopfloor
  - ~50 machine tools

Testbed location 5G-Industry Campus Europe

Fraunhofer IPT shopfloor with lineup of machines

Testbed location 5G-Industry Campus Europe



IPT shopfloor aisle

5G mmW & LTE

5G vibration sensor inside 5-axis milling machine

Fraunhofer IPT shopfloor & radio equipment

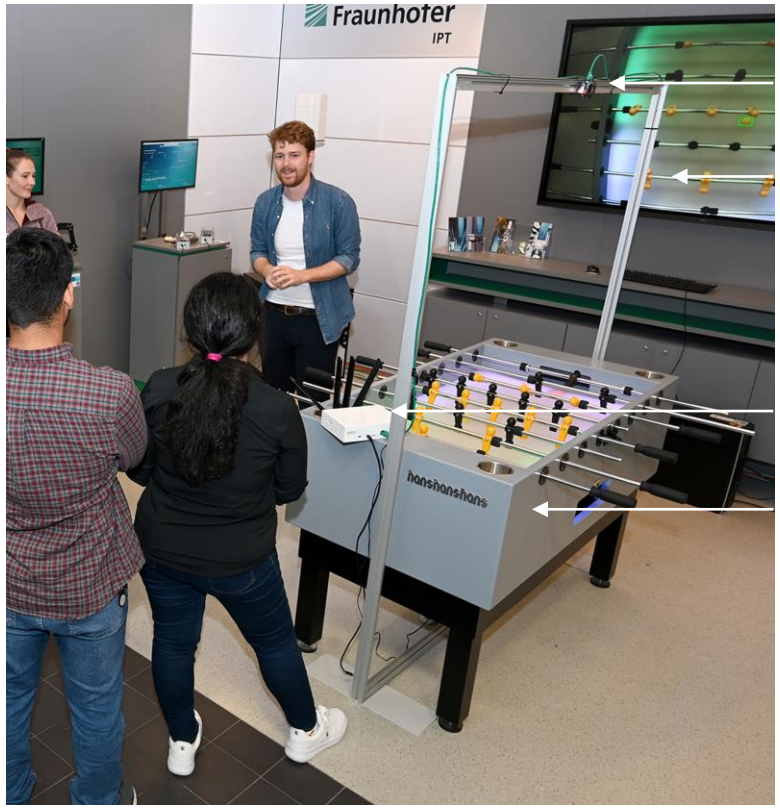
First testbed results

mmW coverage on industrial shopfloor

- Peak rates: UL > 4.2 Gbit/s, DL >1.2 Gbit/s
- Strong signal decline with distance (RSRP>20 dBm @50 m)

First testbed results

5G-enabled Table Football

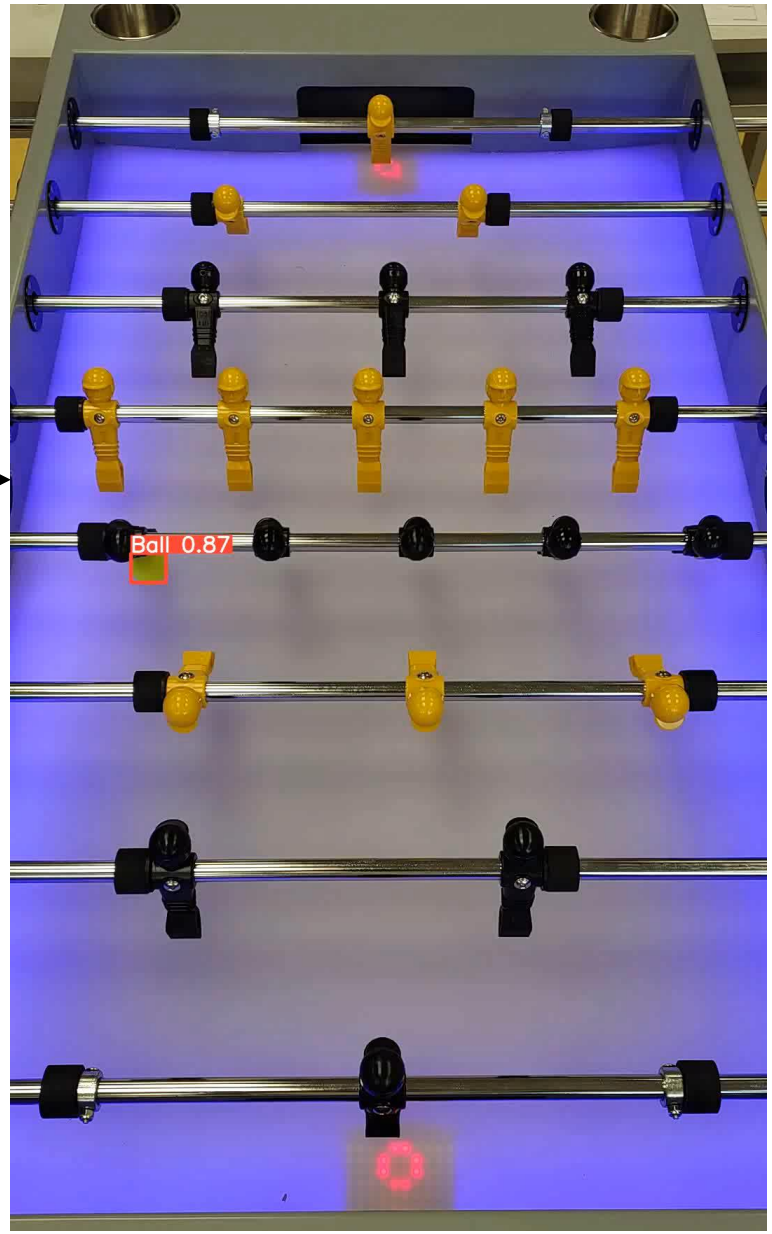


GigE camera @ 120 fps

AI-processed live video

Quectel EvKit with
RM510Q M.2 for mmW

Professional Table Football



Challenges ahead and outlook

- **Harnessing the best of two worlds – combine FR1 and FR2**
  - Use NR-DC to furthermore increase bandwith
  - Operate bandwith-heavy use cases and URLLC use cases via simultaneously using FR1 and FR2 (e.g., machine vision and fieldbus comunication, e.g., CC Link IE TSN, ProfiSafe
  - Add intelligence to orchestrate use cases and allocate them to FR1 and FR2
- **Improve device ecosystem**
  - Market available device for mmW do not support 5G-SA
  - Support of band combination for NSA differs from FR1
- **Use Reconfigurable Intelligent Surfaces (RIS) to enhance coverage for FR2**
  - Attentuation for FR2 is significantly higher than for FR1 – close to line-of-sight (LOS) dependency
  - RIS can be used to cover blocked areas (e.g., inside machine tools, crossings)
  - Static RIS might be used in combination with active antennas

Thank you for your attention!

ご清聴ありがとうございました！

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Backup: Signal Quality & Coverage mmWave @IPT

RSRP of all n258 PCIs