THz Point-to-Point Links:

>100 GHz; >100 Gbps

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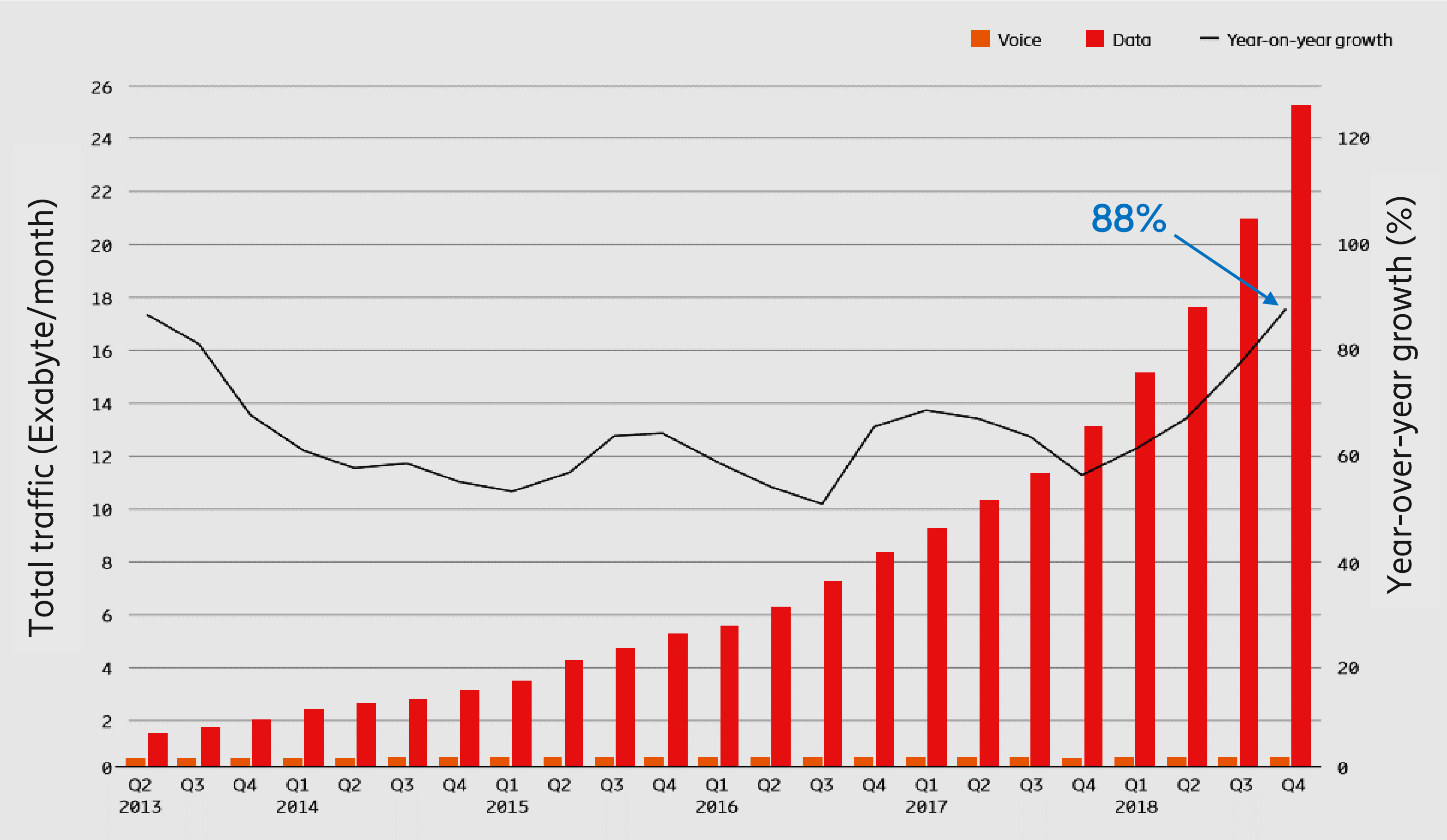
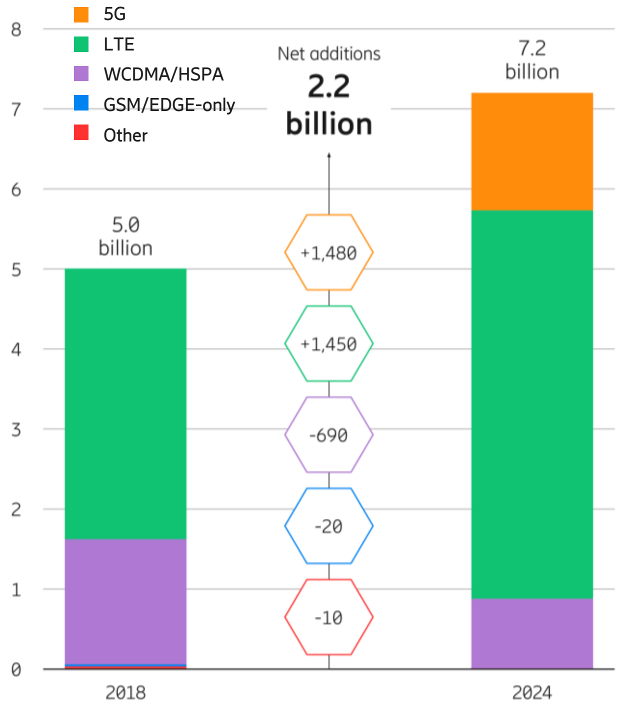
- Spectrum Horizon
- Challenges
- Ex. D-band research and development
- Some future perspective

Global mobile traffic growth (based on measurement):



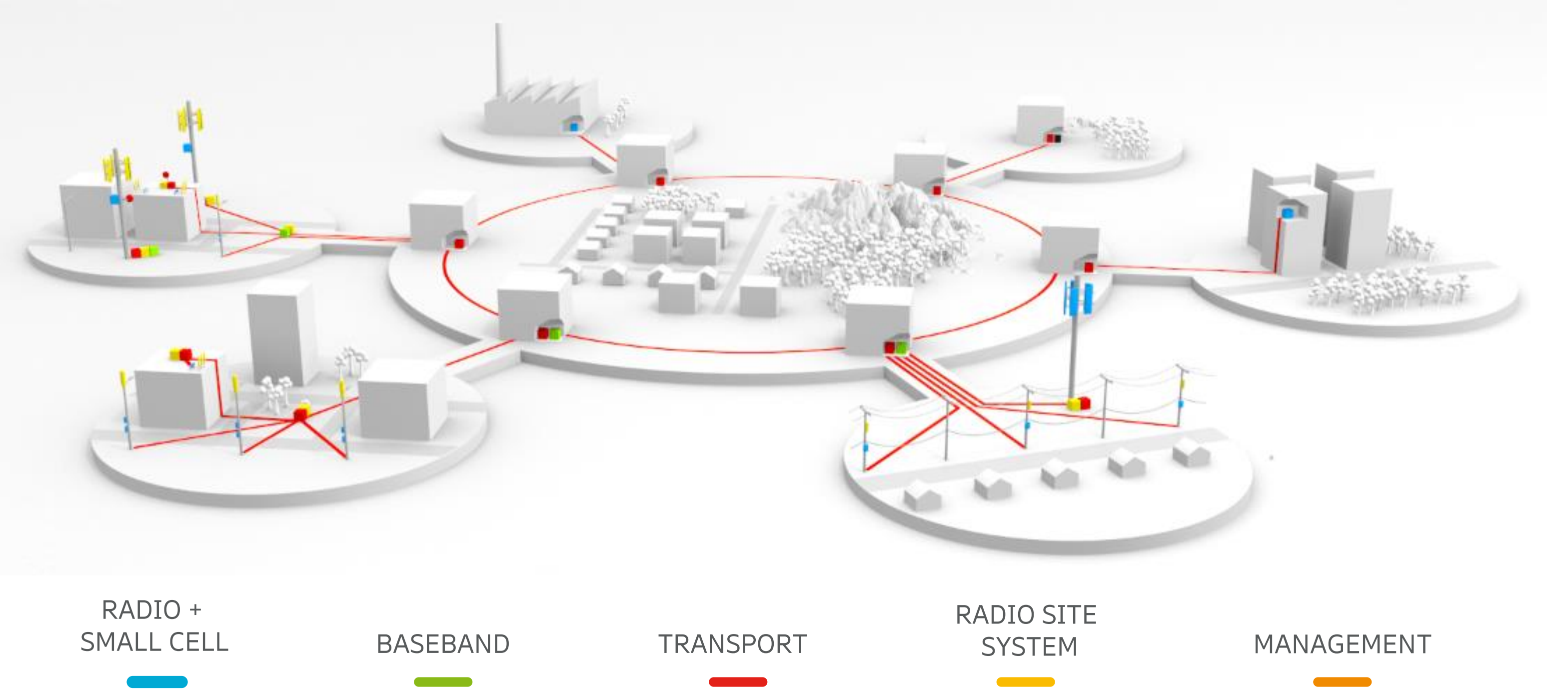


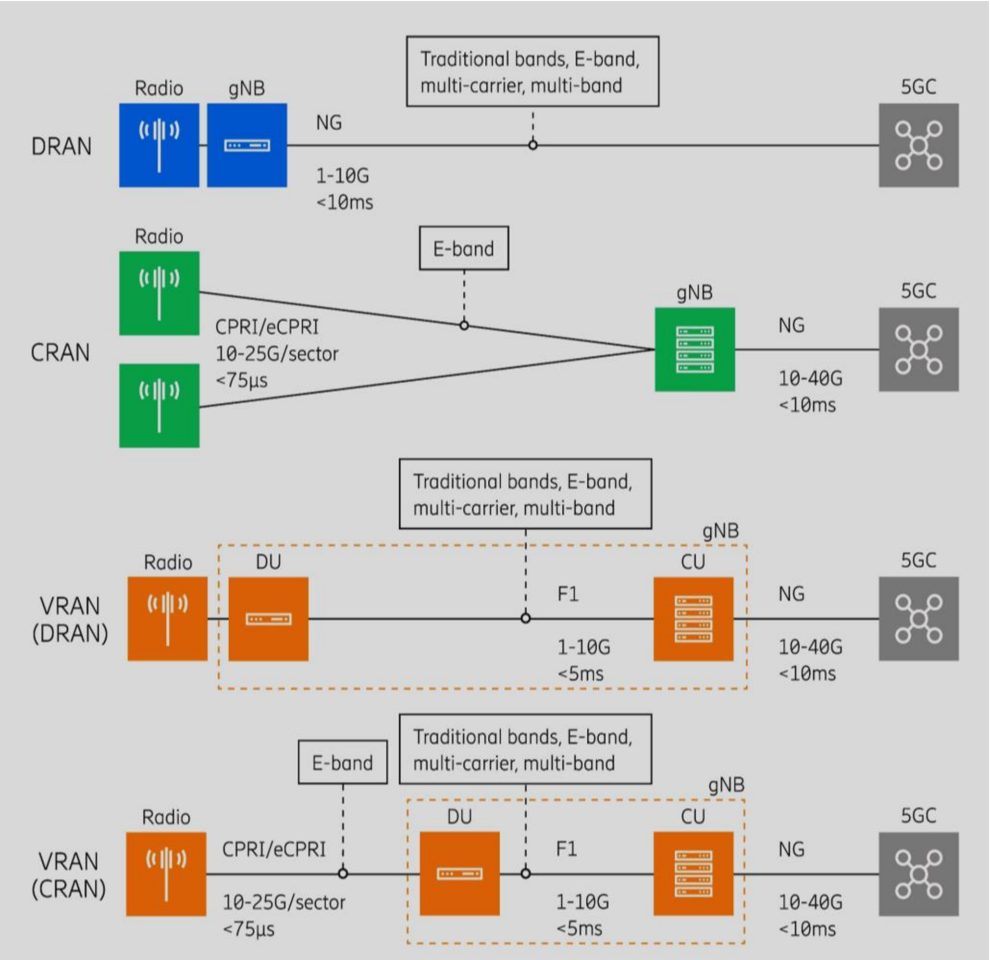
Smartphone subscriptions by technology

Transport networks

Evolving in:

- Network dimensioning, architecture and topology
- Capacity





Future transport needs

Backhaul capacity per site in Distributed RAN

	2018 Low — high cap sites	2022 Low — high cap sites	Towards 2025 Low — high cap sites
Urban	150 Mbps — 1 Gbps	450 Mbps — 10 Gbps	600 Mbps — 20 Gbps
Suburban	100 Mbps — 350 Mbps	200 Mbps — 2 Gbps	300 Mbps — 5 Gbps
Rural	50 Mbps — 150 Mbps	75 Mbps — 350 Mbps	100 Mbps — 600 Mbps

C2 (eCPRI) capacity in Centralized RAN

	2022 Low — high cap sites	2025 Low — high cap sites
Massive MIMO (1 sector)	10 — 15 Gbps	15 — 25 Gbps
Massive MIMO (3 sector)	15 — 25 Gbps	25 — 40 Gbps

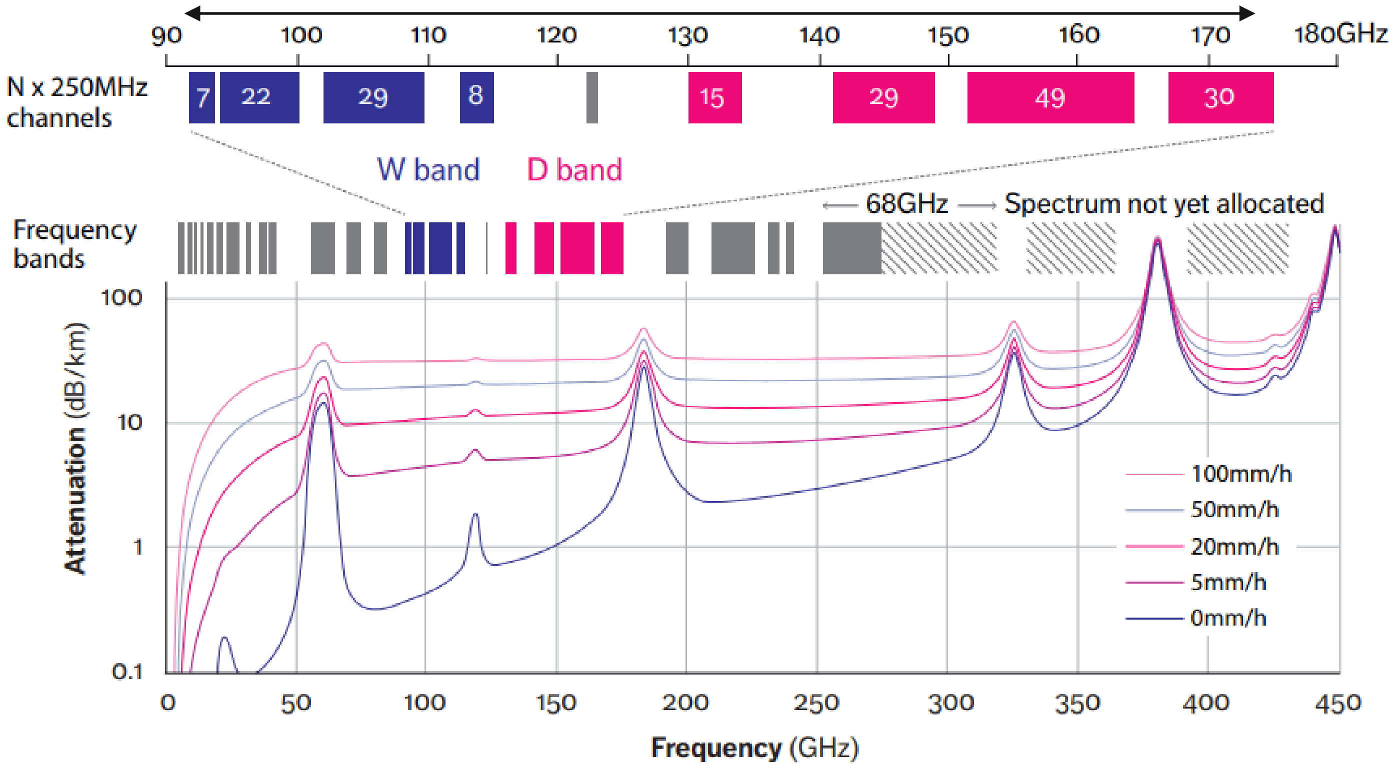
Source Ericsson (2018)

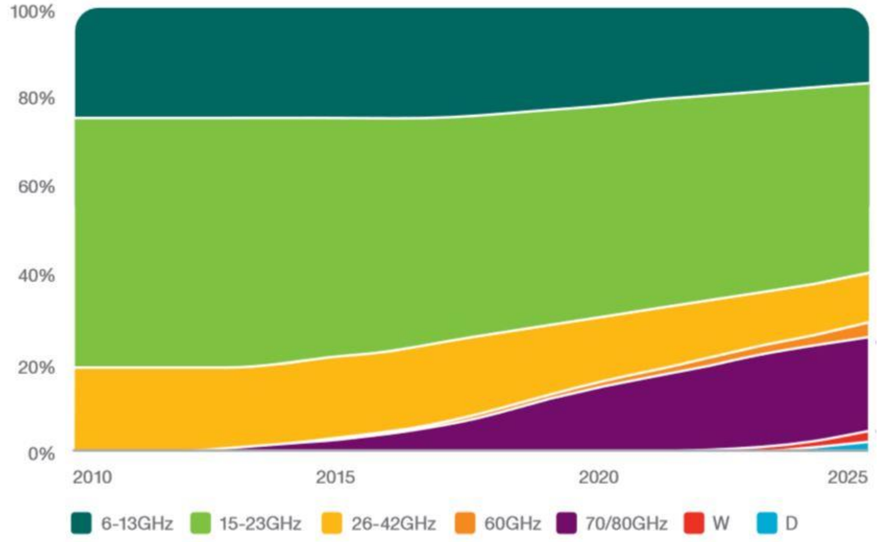
Spectrum Horizon

In commercial use
W-band, to be commercialized
D-band, to be commercialized
5G candidate band
5G candidate band but prioritized for backhaul

The W-band and D-band

46.5 GHz for wireless communication

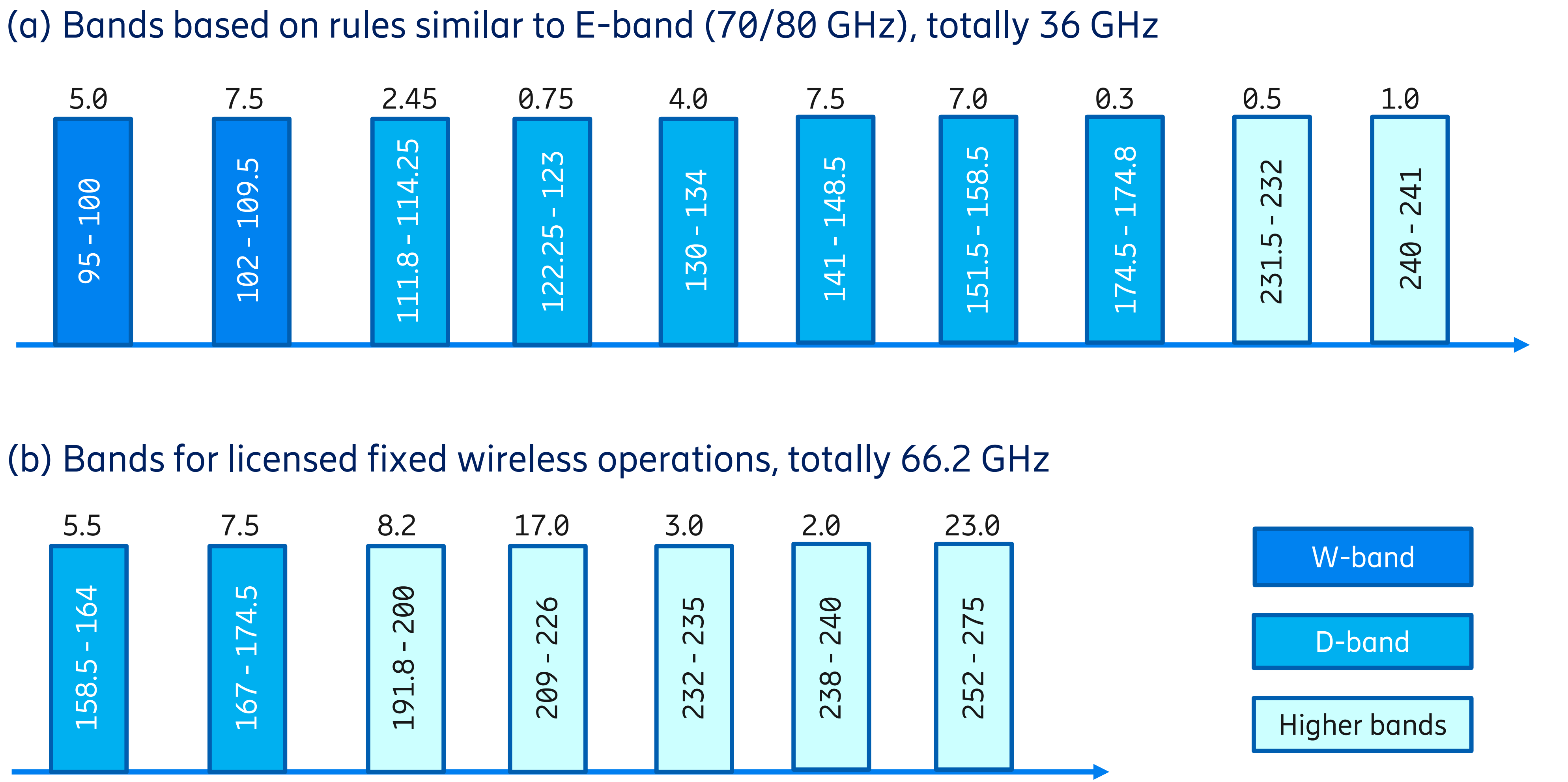




Deployment share per frequency
(Source Ericsson 2017)

Source: Ericsson Technology Review 2017, https://www.ericsson.com/assets/local/publications/ericsson-technology-review/docs/2017/etr-beyond-100ghz.pdf

FCC Spectrum Horizon: *up to 275 GHz proposed*

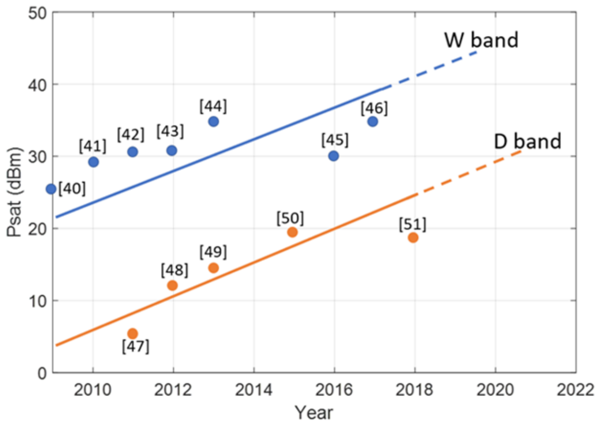


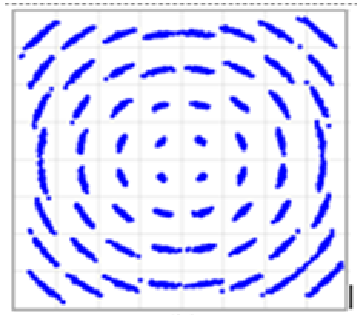
(source: Ericsson/Yinggang Li)

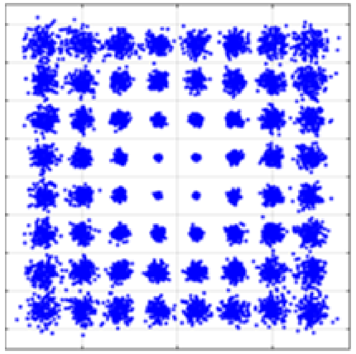
Technical challenges when approaching sub-mmW:

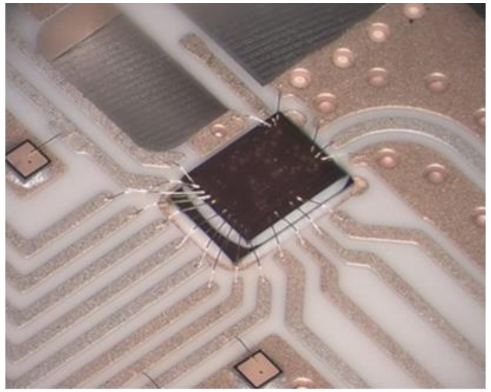
- Output power varies generally as $1/f^{\alpha}$ α=2~3
- Packaging becoming increasingly difficult
  - if possible: integrate the antenna on-chip or in package
- Unwanted resonance modes may easily develop in MMIC substrate
- Modeling increasingly difficult at high frequency
- Phase noise increasing (typically 6 dB per frequency doubling)
- Receiver noise figure increasing

➔ *General statement:* S/N degrades fast with frequency!

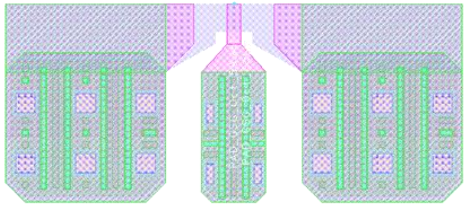








Wire-bonding, E-probe, backshort for transition, mmW substrate

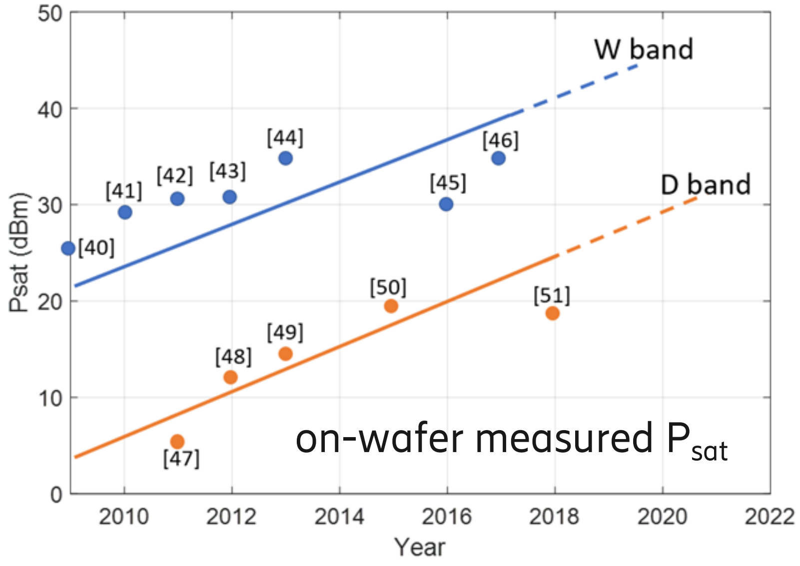


D-band RF pad, 30x60 μm^2, challenging for wire bonding

How to transfer the "precious" mmW power from MMIC to antenna port?

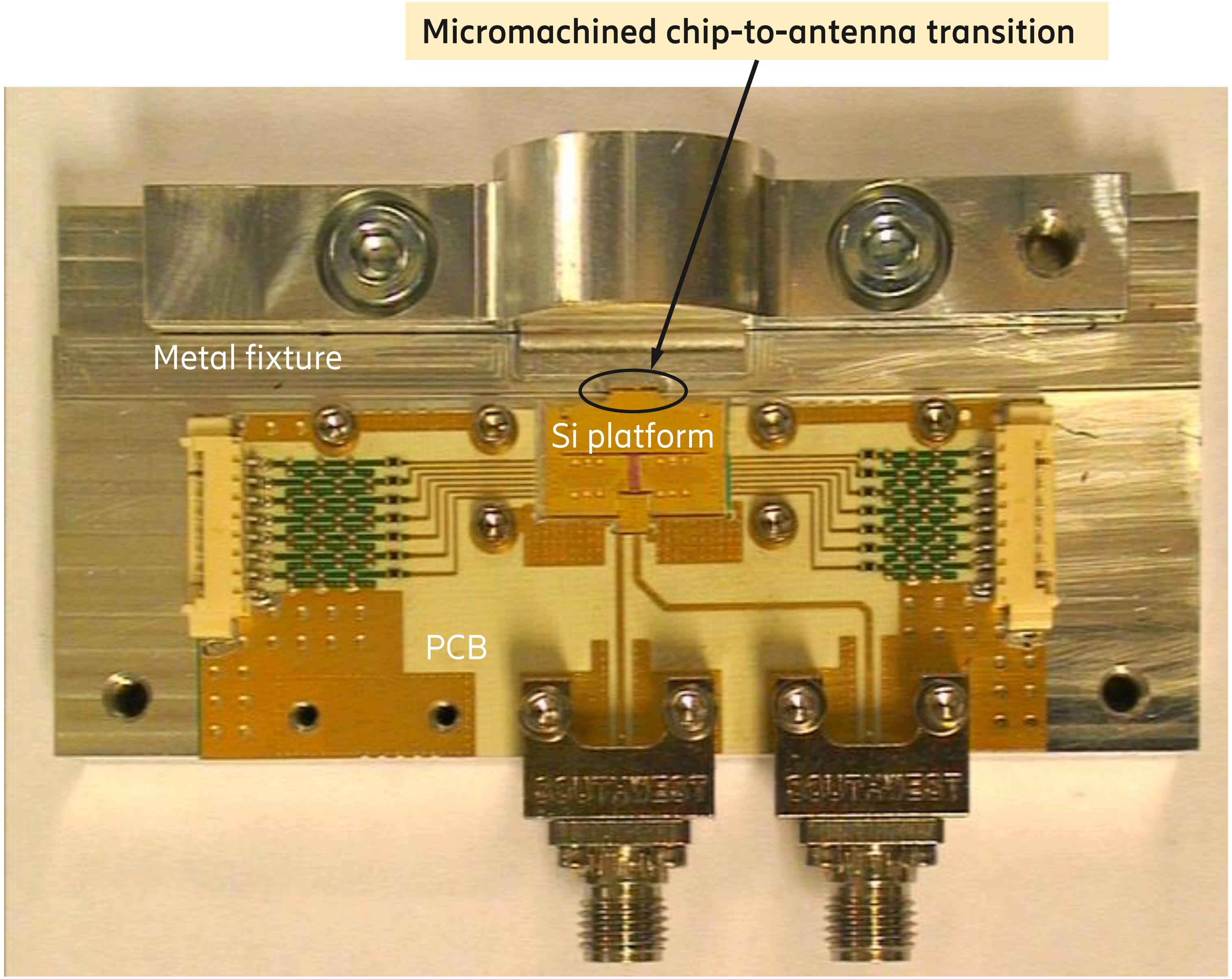
The solution must be:

- Volume manufacturable
  - Automatically assembly, repeatability (yield), tolerance insensitive, etc.
- Commercially affordable



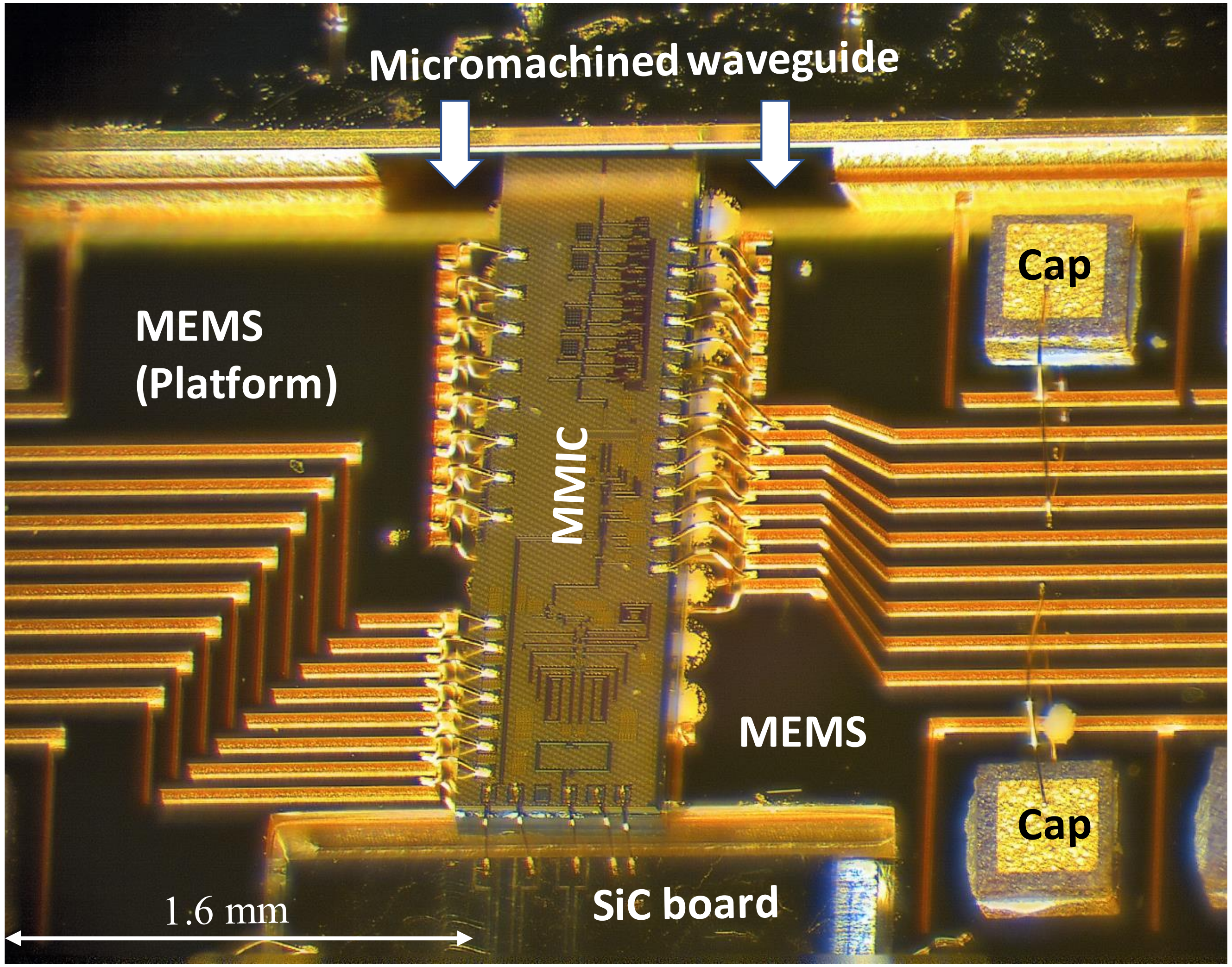
Example, D-band transceiver modules for PtP links

- M3TERA, a H20202 project
- PoC demonstrator: *D-band Tx/Rx module*
- MMICs in 130nm SiGe from Infineon (B11)
- Micromachined Si substrate as an heterogenous platform for system integration

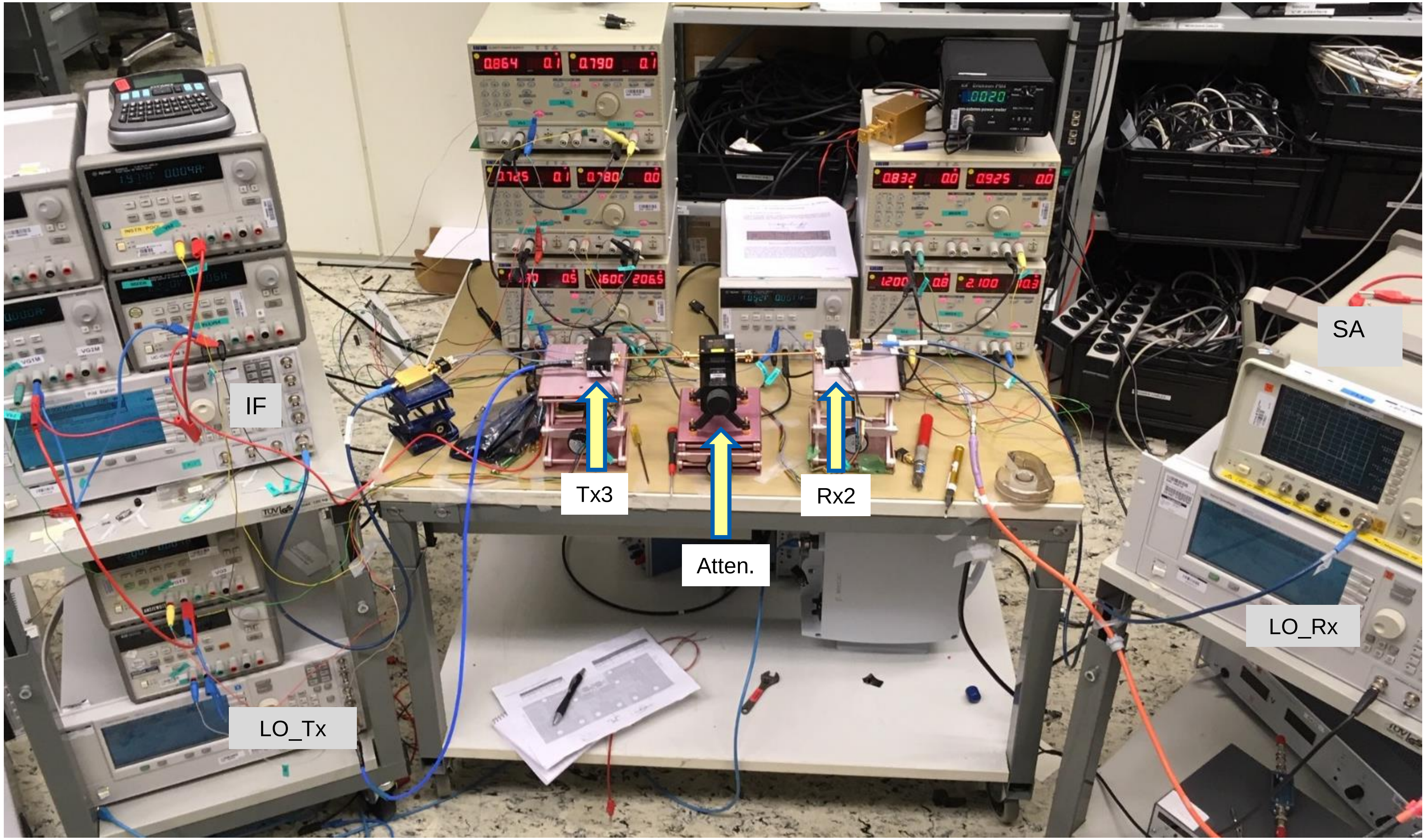


Heterogenous integration based on micromachined Si substrate

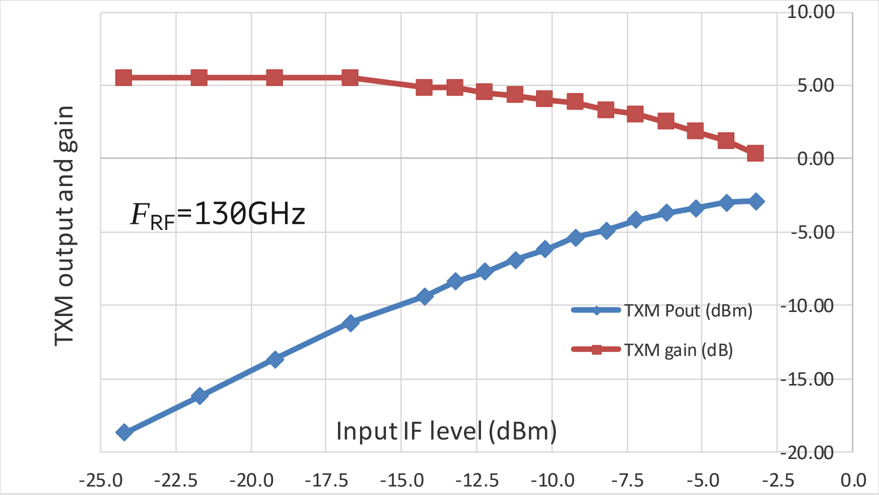
- Micromachined low-loss Si waveguide
- Non-gavanic transition between MMIC and the waveguide
- Embedded components, e.g. BPF, duplexer and phase shifters

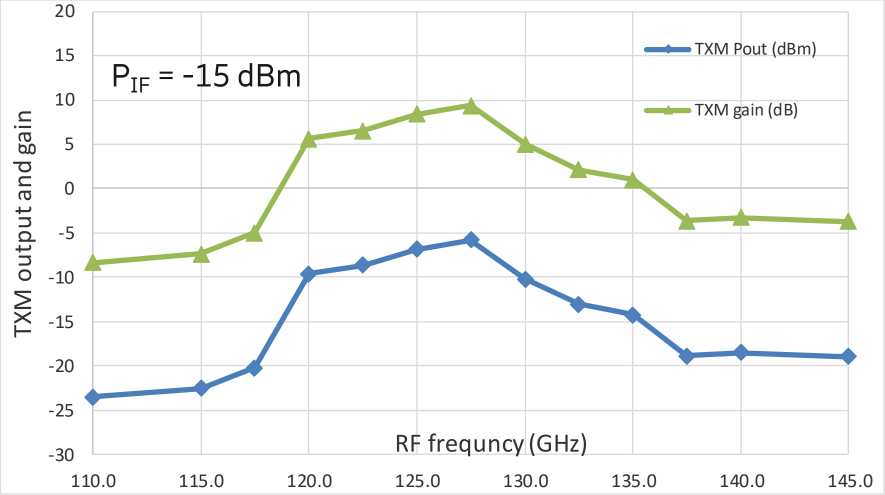


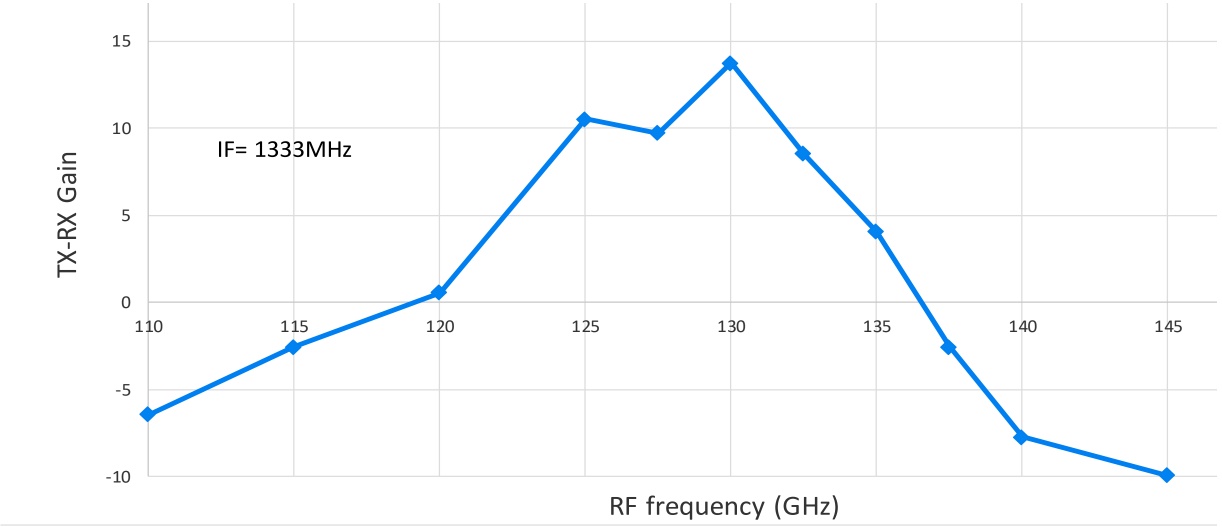
Link test setup



CW test

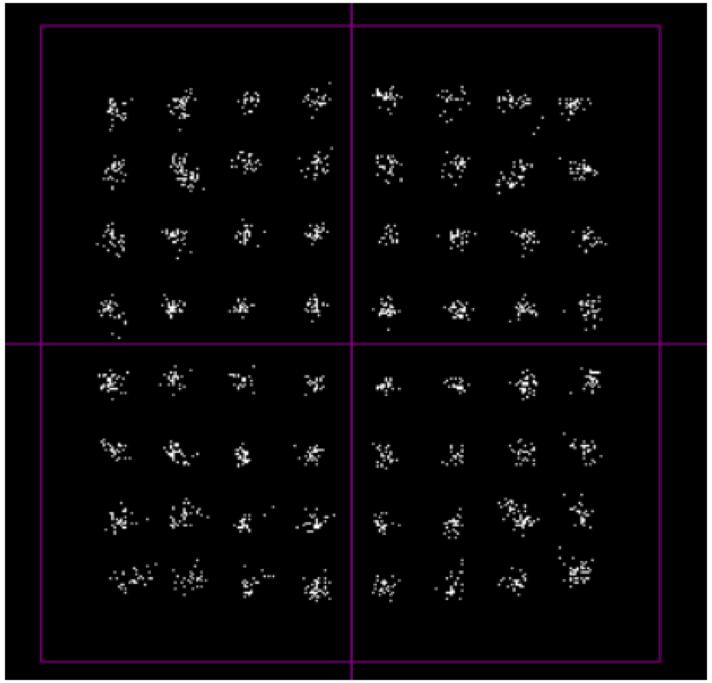


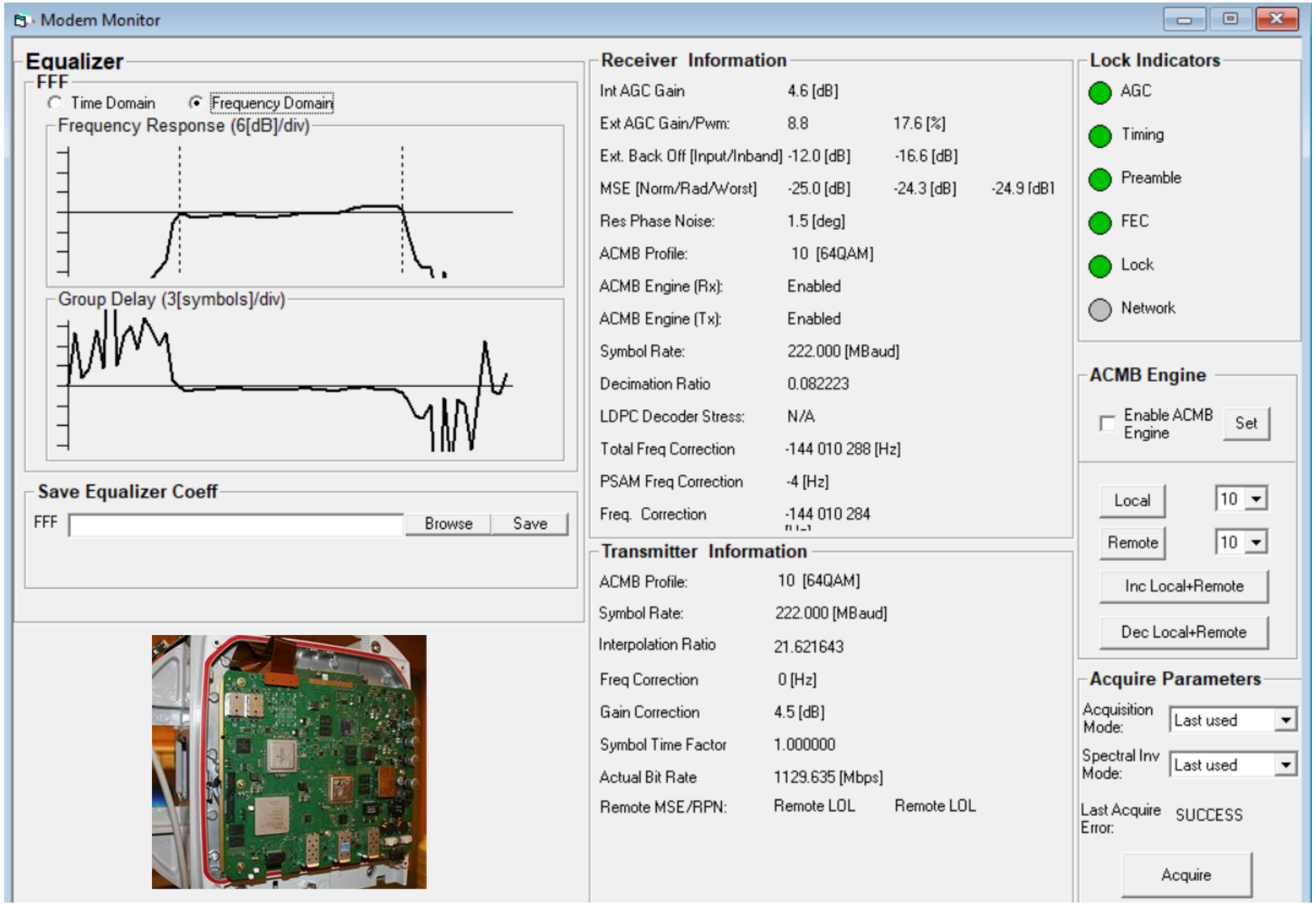




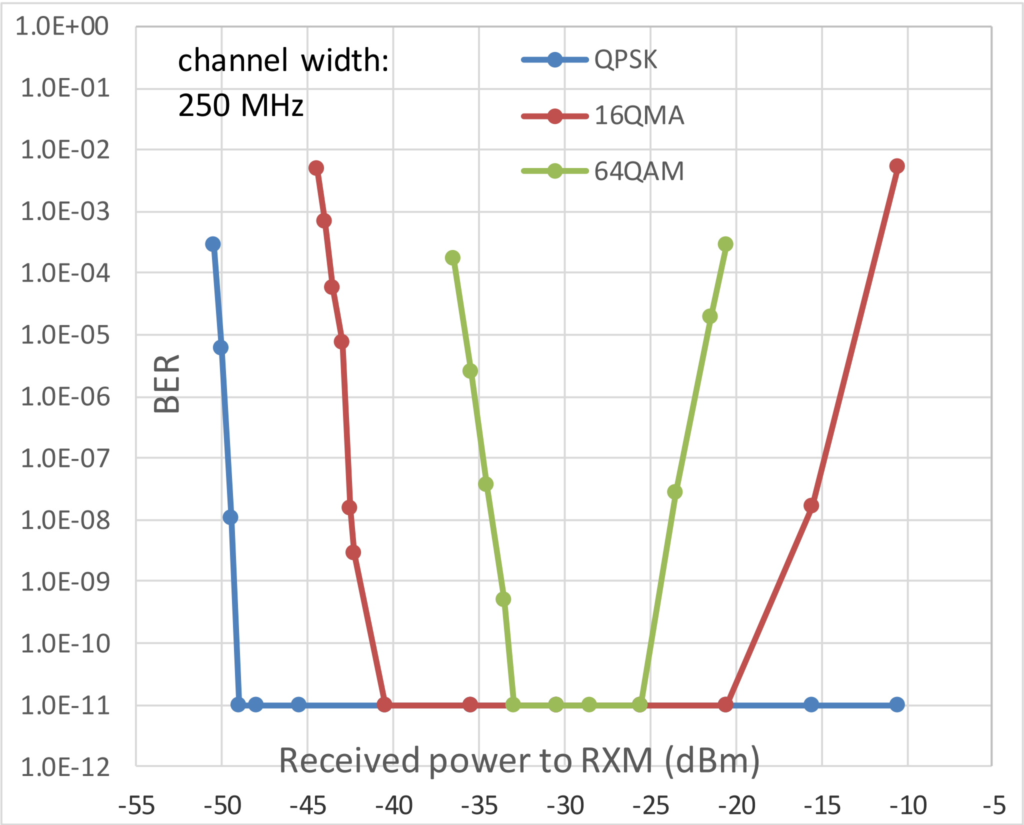
- Peak gain position (frequency) depend strongly on bias
- Bandwidth depends strongly on bias

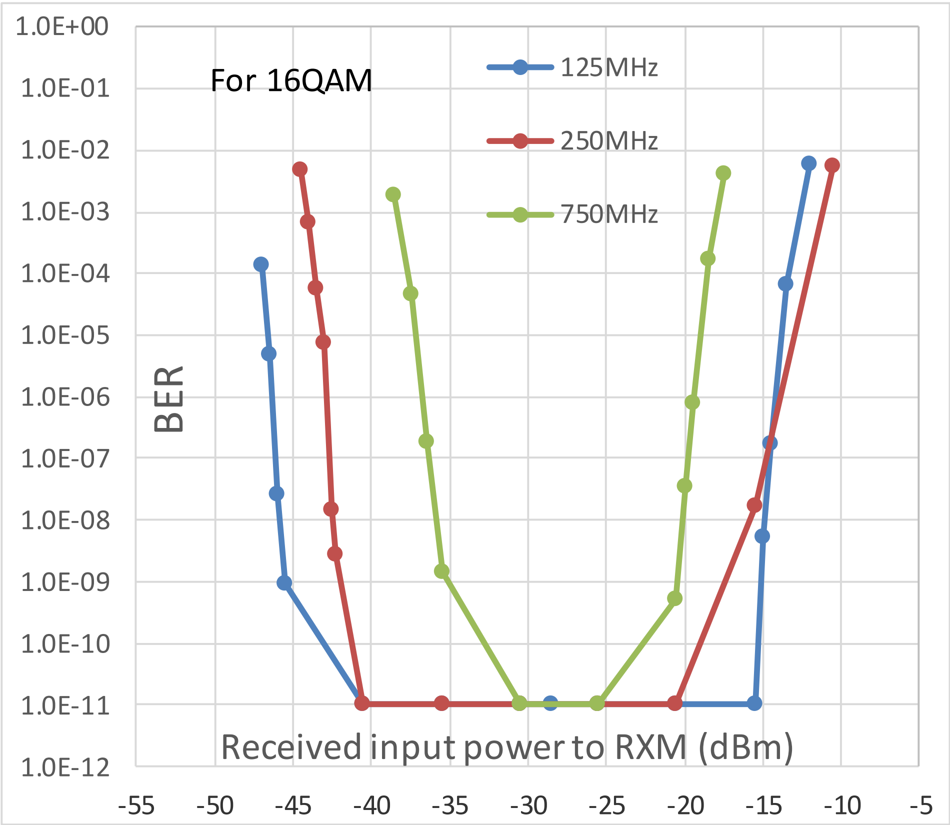
Real-time data transmission based on Ericsson's Modem





Measurement results





100 Gbps microwave link is not a dream any more today but a reality!

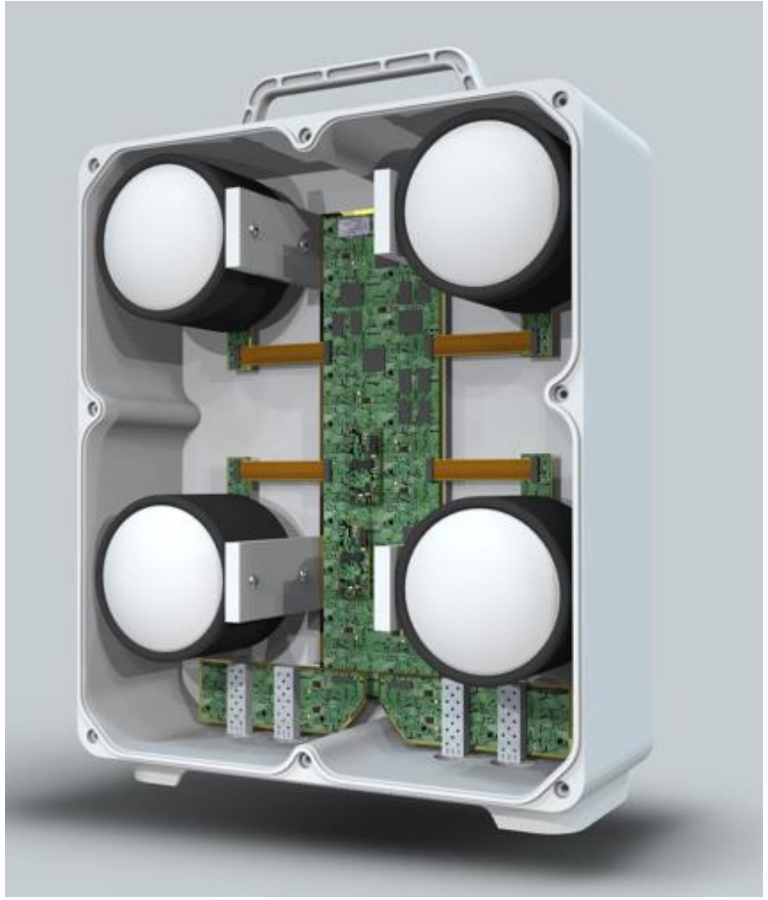
- Demonstrated by Ericsson in Gothenburg, Feb. 2019
- Based on Ericsson's existing commercial product
- Line-of-sight MIMO plus H/V polarization

Purposely removed!

Looking forward

- > 100 GHz
  - Short-term: W- & D-band
  - Longer term: towards sub-mmW (275 GHz)
- > 100 Gbps
  - Microwave solutions available today to meet the need for 5G towards 2025
  - 100 Gbps for beyond 5G towards 2030
    (Tbps from even longer-term perspective ?)
- Compact and simplified site solution for MIMO and high-gain antennas towards sub-mmW
- Challenges with THz MMIC interconnect and packaging
  - Heterogenous system integration
  - Antenna-in-package and SiP

➔ Continuous and sustained research effort is necessary to commercialize the mmW-THz spectrum



Perspective for future D-band LoS-MIMO