5G mmWave for Road and Rail

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Cambridge Wireless
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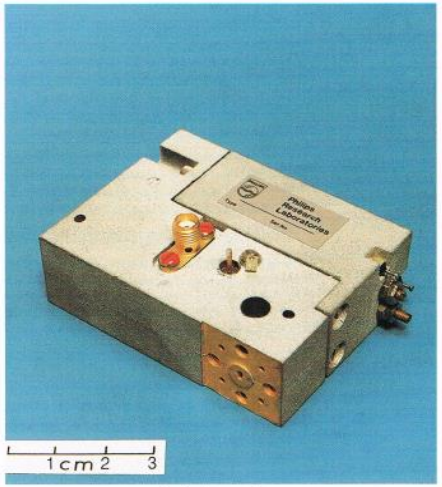
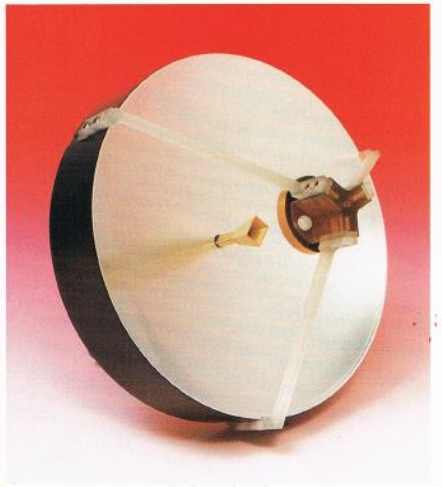
‘Simply Years Ahead’ – Philips Research 1984

OAR 94
Obstacle Avoidance Radar



Radar Transceiver.


Antenna Head

The lightweight FMCW radar head produces an output frequency spectrum with frequency components proportional to the ranges of the targets present.

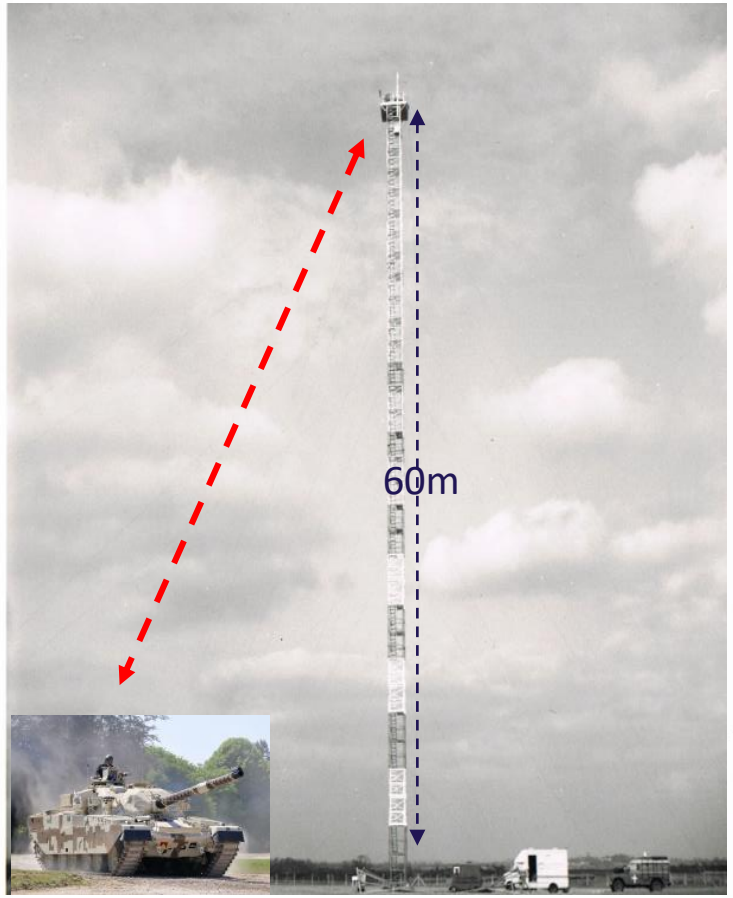
The spectrum is analysed by a Fast Fourier Transformer (FFT), in the processor, to generate coherent radar video signals. These signals can be combined with information from the scanner position sensors and attitude sensors on the helicopter to generate the equivalent of a three dimensional Plan Position Indicator (PPI) within the processor. This information is then analysed by the processor to extract the positions of any obstacles in front of the helicopter. The processed information is presented to the pilot on a simple display to enable him to see immediately the direction of any obstacles, and where he can fly safely.

The radar has a beamwidth of 5 m at 200 m range, giving enough accuracy to enable the pilot to fly under power lines if necessary.

The use of a 94 GHz Frequency Modulated Radar gives the following features

- High reliability
- Low weight
- Low cost
- High resolution
- Compact
- Very high ECCM (Electronic Counter-Counter Measure) Performance

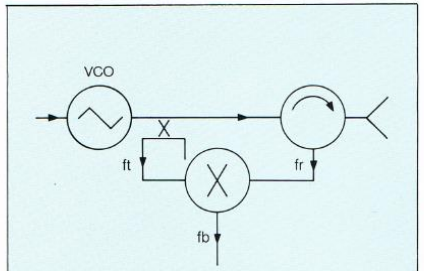
PHILIPS



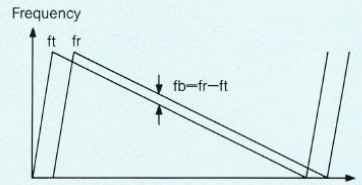
Tentative data

Output power:	10 mW	Detection range: (99.99 % detection probability)	
Coverage:	±15° in elevation by ±90° in azimuth	3 mm wire	600 m
		14 mm wire	900 m
Angular resolution:	1.5° azimuth and elevation	1 sq metre target	550 m
Range resolution:	5 m.	Weight: Scanner	1.5 kg
Update rate:	1 Hz.	Processor	5 kg
False alarm rate:	1 per thousand hours.	Indicator	0.5 kg
Indicator:	Audiable warning + “danger zone” display.		

Principle of operation



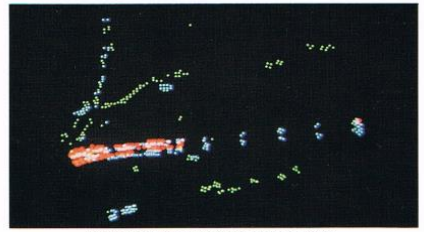
Simple FMCW schematic

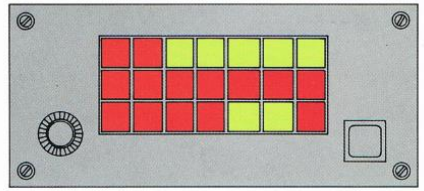


Sweep characteristics

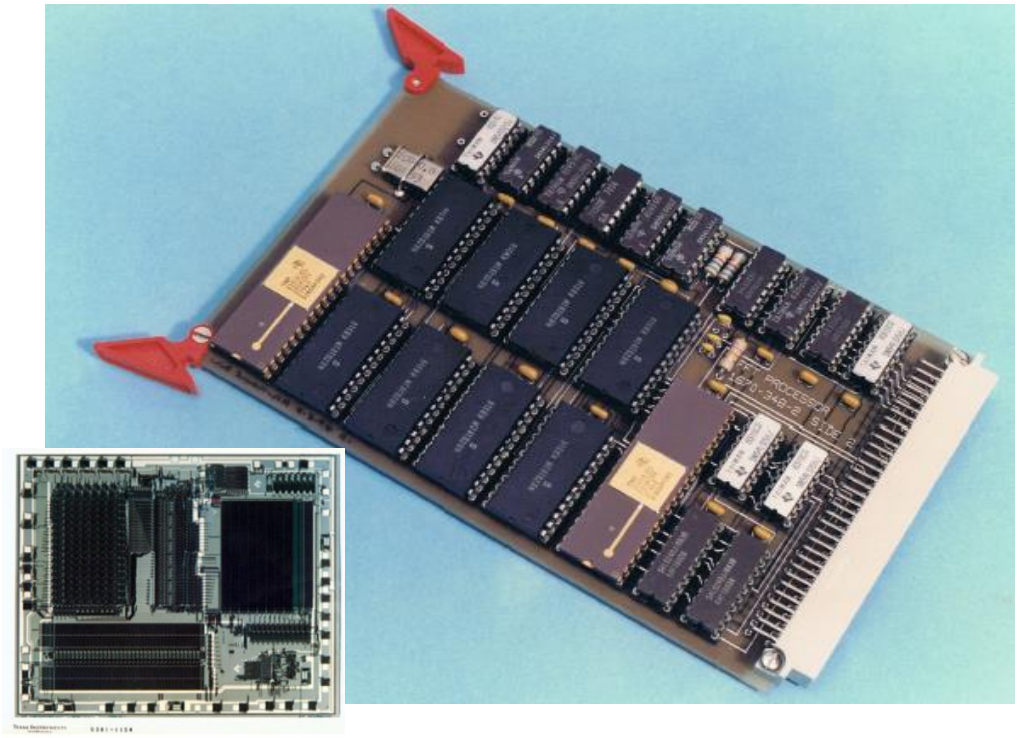
Principle of presentation


View of power line


Radar PPI presentation of the obstacle


Cockpit display of the same obstacle

◎ Wireless Baseband (R)evolution over 35 years

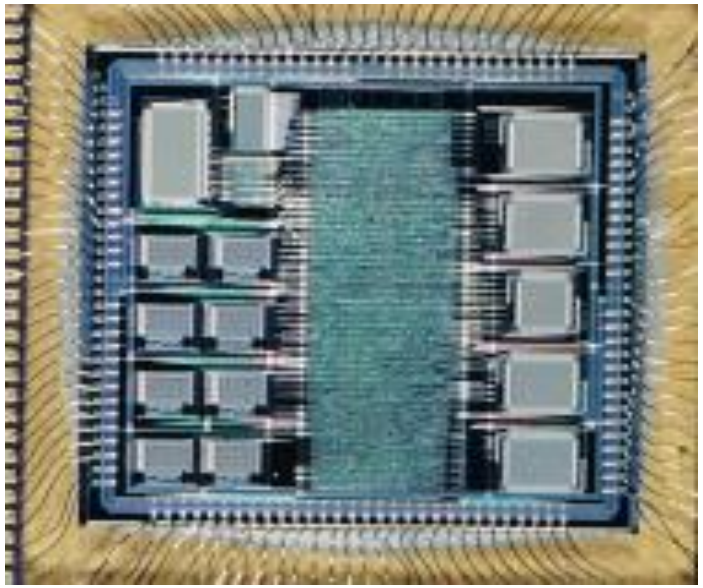


1984 : Dual DSP FFT Processor (PRL)

Texas TMS32010 : 64pt FFT <1 msec

5 MOPs @ 20 MHz

2.5um NMOS



1991 : Digital Beamformer (ERA)

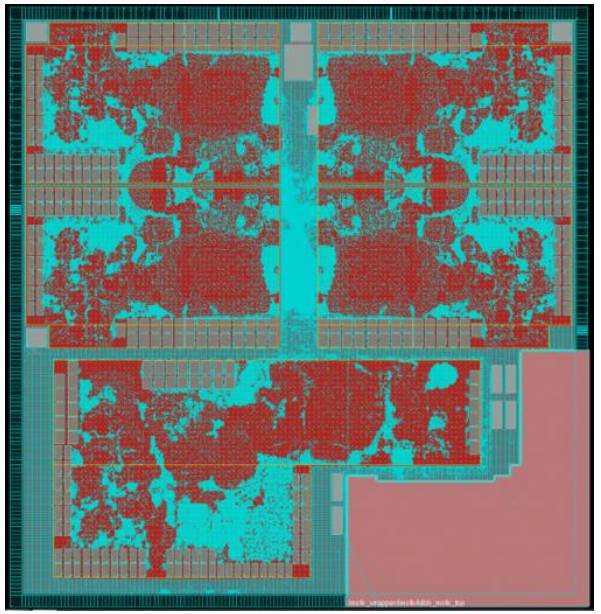
4x8MHz IQ sample rate / DBFN

Cascaded to 20+ elements

Adaptive beamforming support

200 MOPS @ 32 MHz

1um CMOS



2014 : PHY1 Gigabit modem (BWT)

5x PPU SIMD Vector DSP

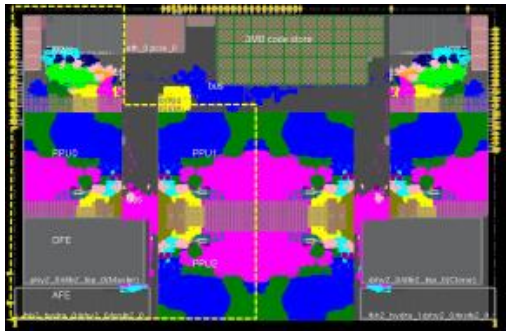
512 pt FFT < 300 nsec

2,000 GOPs @ 500 MHz

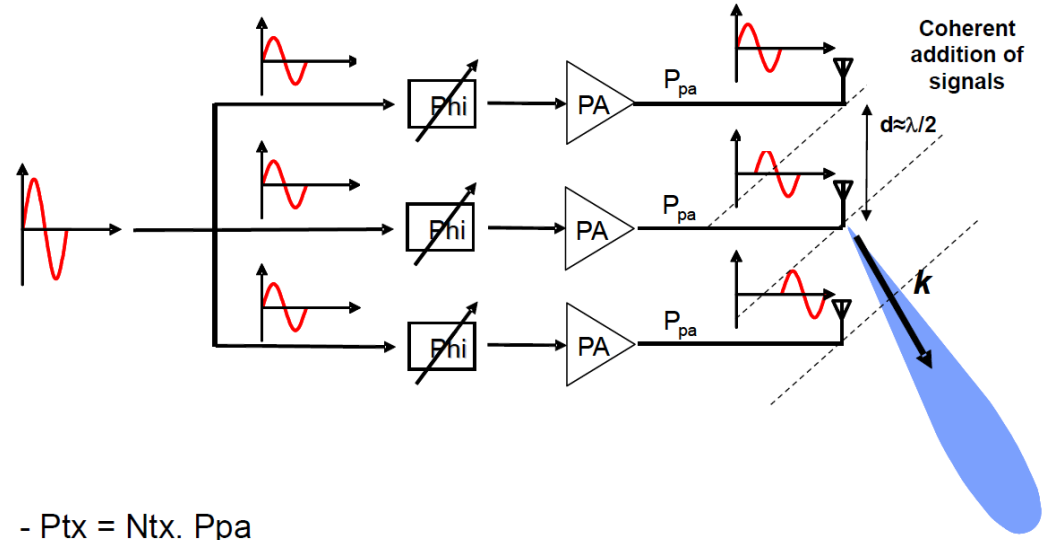
40 nm CMOS inc 2.6GHz IQ AFE

◎ Blu Wireless

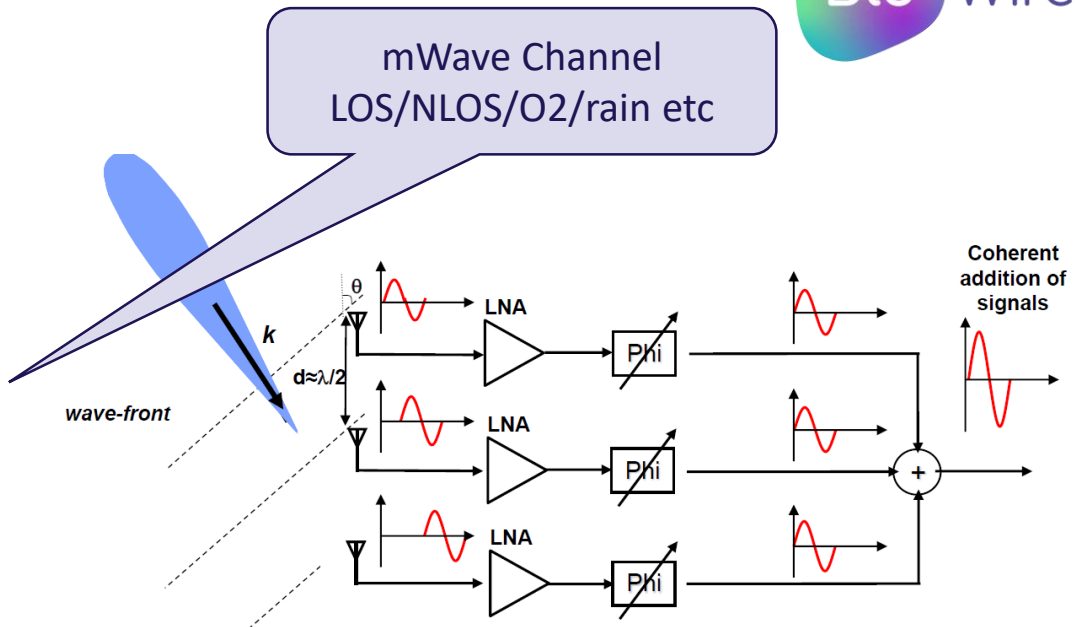
- Gigabit mmWave technology for
  - mmWave modem SoC and software
  - 5G FWA and Backhaul
  - High speed Transport Road and Rail
- Track to train connectivity trials in 2018
- First commercial 5G mmWave rail deployment in 2019 with First Group on SWR line
- Partner in ‘Autoair’ and ‘L5G’ 5G Test Beds
- Members of Wi-Fi Alliance, ETSI mWT ISG groups, UK 5G IC and Facebook TIP
- Bristol UK and Hyderabad India, 80+ staff with investors led by ARM and Calculus. US and Japan sales



Active Phased Array Principle



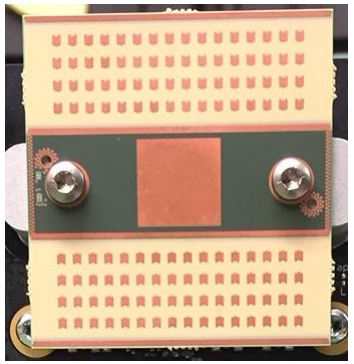
- Ptx = Ntx. Ppa
- EIRP = Ntx .Ppa → EIRP_total = $(Ntx)^2$ .Ppa

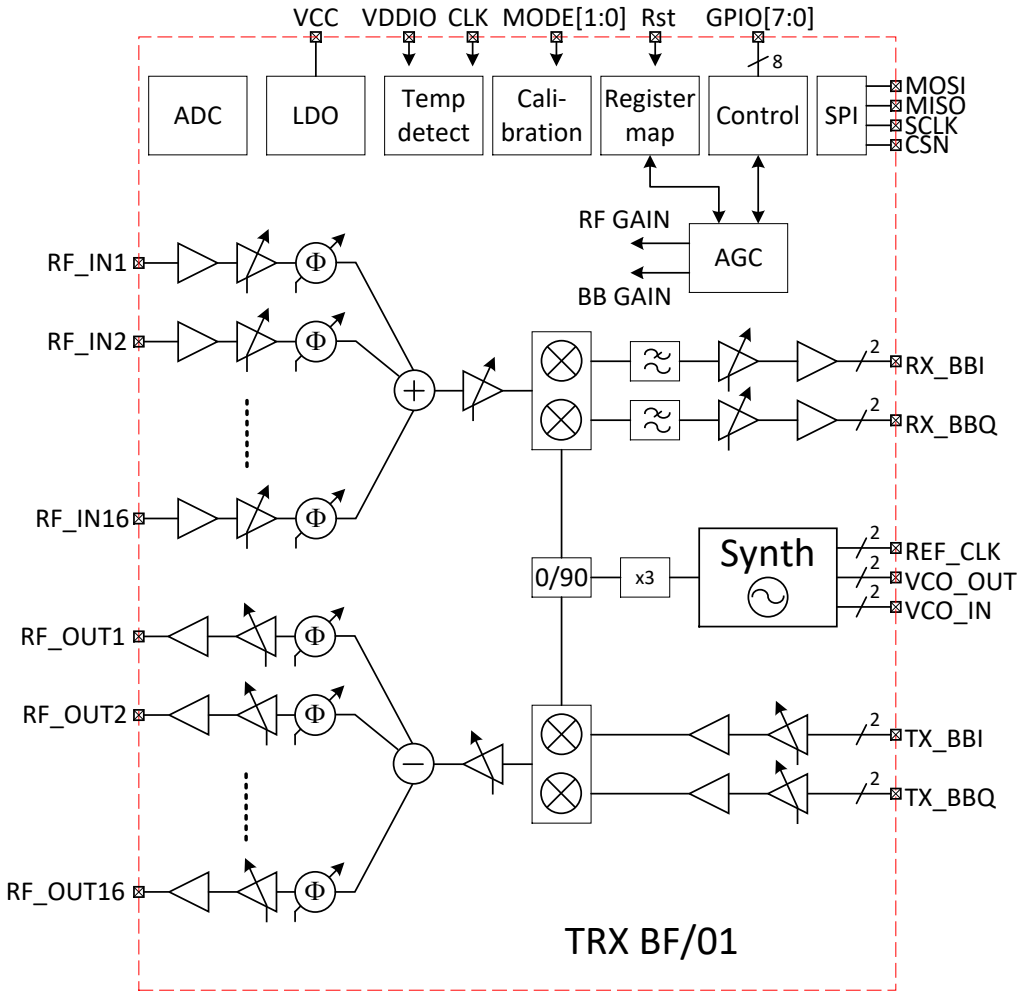


Prx = Nrx^2.Prx_el
Pn = Nrx. Pn_el → SNR_total = Nrx .SNR

- Tx - combination of spatial power combining and beam forming enables 60GHz transmitter implementation in VLSI RF (CMOS, SiGe etc) : 20*Log(Ne)
- Rx - combination of power combining and beam forming improves overall NF of the receiver system : 10*Log(Ne)
- Path loss inc. Tx and Rx gain **reduces** by F^2 for constant antenna aperture

‘Eder’ 60 GHz Phased Array RF IC

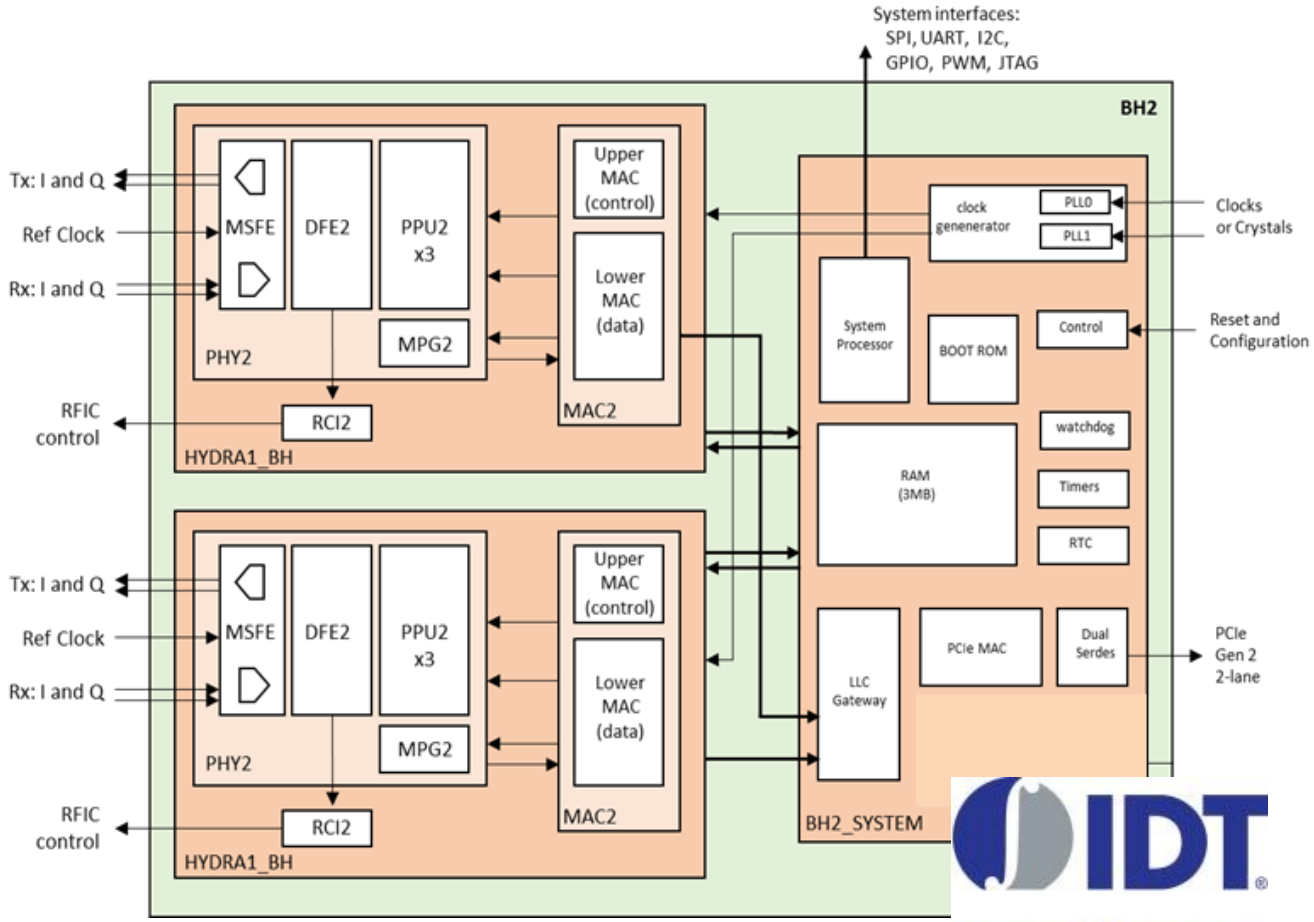




- Beamforming Transceiver with 16 RX + 16 TX channels
  - RF Module with +23 dBi gain
  - +/-45 degrees Azimuth coverage
  - Excellent EVM
  - PoEIRP up to **+43dBm**
- IEEE 802.11ad compliant **57-71GHz**
- Support for **64QAM**
- Modular integration with the digital Modem over analog IQ interface
- SiGe BiCMOS in an e-WLB package
- Geared for infrastructure applications

RWM6050 'HYDRA1.0' Baseband Modem

- Full turnkey SoC in TSMC 28HPC
- Dual HYDRA1.0_BH modem
  - Total throughput of 6 Gbps
  - Extended IEEE 802.11ad/ay PHY/MAC
  - Programmable symbol rate and channel width
  - Support for multiple mmWave RF
    - SiBeam 6342 12+12 59-63 GHz RF
    - **SiversIMA Eder 16+16 57-71 GHz RF**
    - Nokia Bell Labs Tesseract 90 GHz RF (WIP)
  - MAC support for P2p and p2mp & QoS
  - PCIe2.0 dual channel (8 Gbps)
- Power consumption <2.5W dual modem
- LINUX nl80211 Wi-Fi driver support
- Mass Production since October 2018

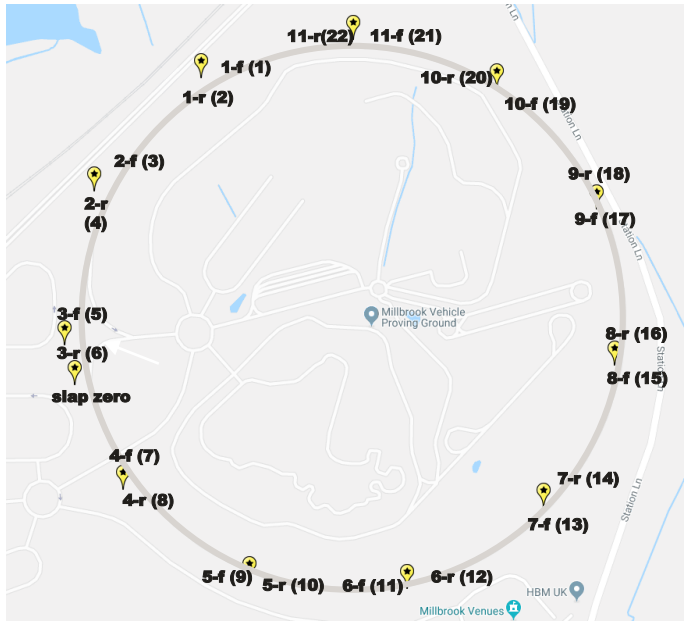


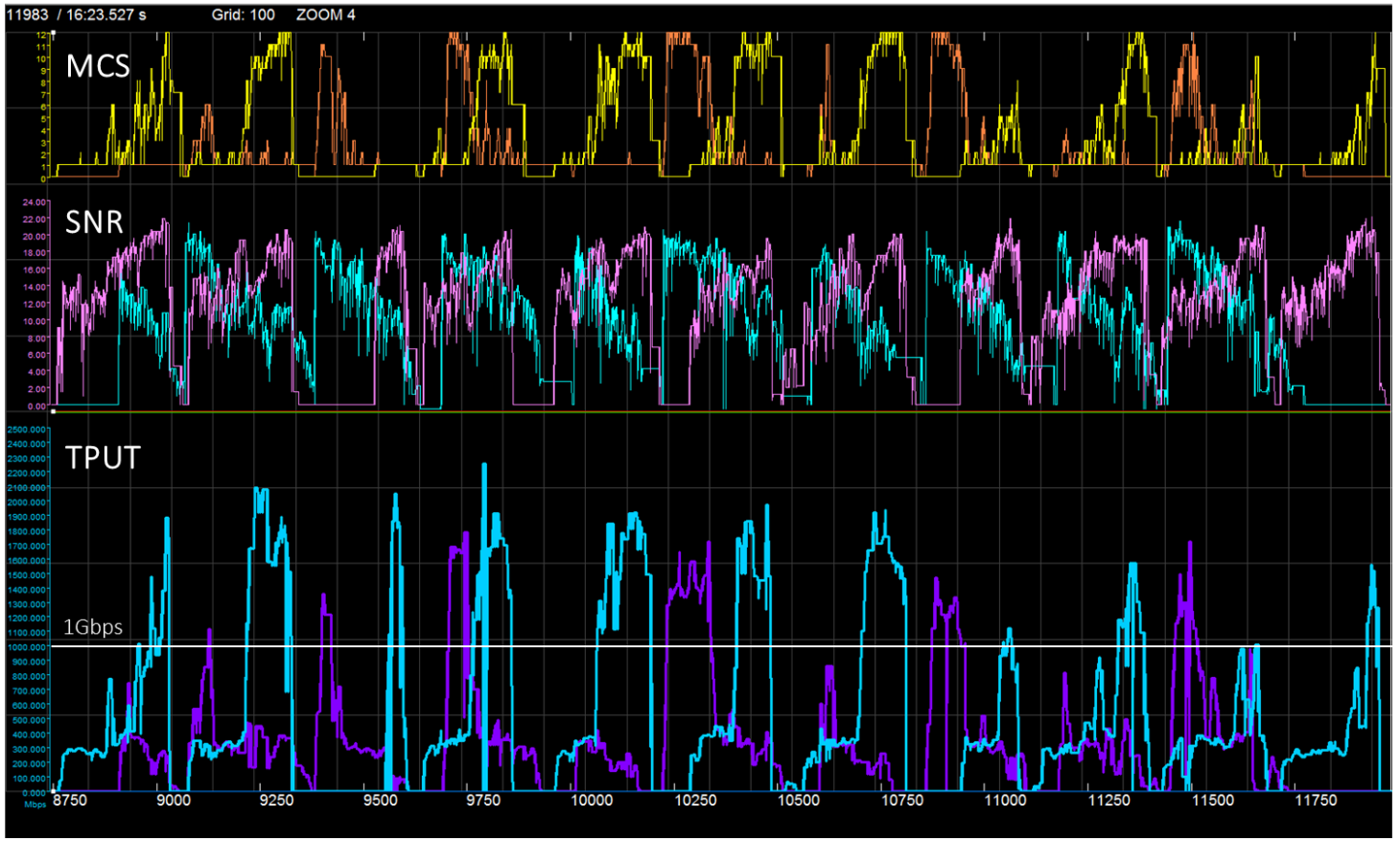
www.IDT.com

‘Typhoon’ Distribution Nodes

- Integrates mmWave RF, modem and LINUX NPU
- Advanced features
  - Fast beamforming based on 802.11ad
  - MAC aggregation AMPDU & AMSPU
  - p2p and p2mp (30 clients) support
  - 1588 TC Synchronisation (5nsec)
  - Cavium Octeon Quad core ARM ‘Enterprise grade’ NPU
  - LINUX driver and programming guide
  - GigE, PoE and SFP interfaces
- Supports multiple RF options
  - 59-63 GHz SiBEAM (DN101LC)
  - 57-71 GHz SiversIMA (DN101SC)
- Applications
  - Technology Evaluation Platform (via Open API)
  - Field Trial Platform (robust and weather proof)
  - Small-deployment Network trial networks
  - Vertical applications such as Transport

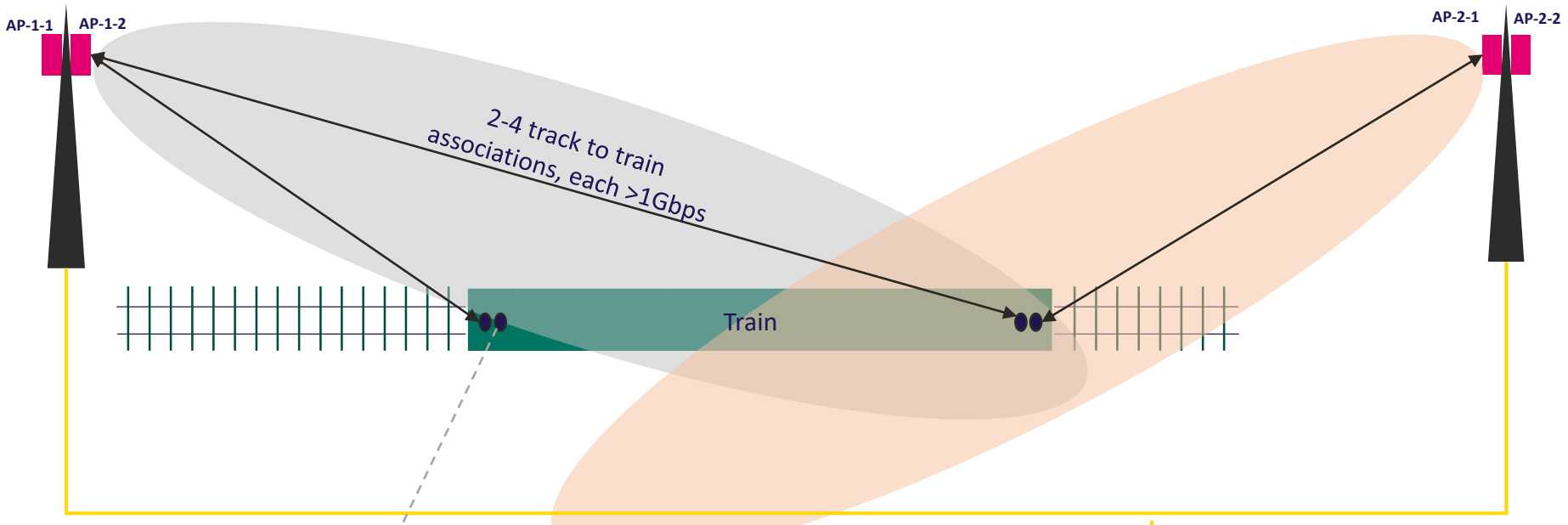
Autoair - mmWave Testing at Millbrook





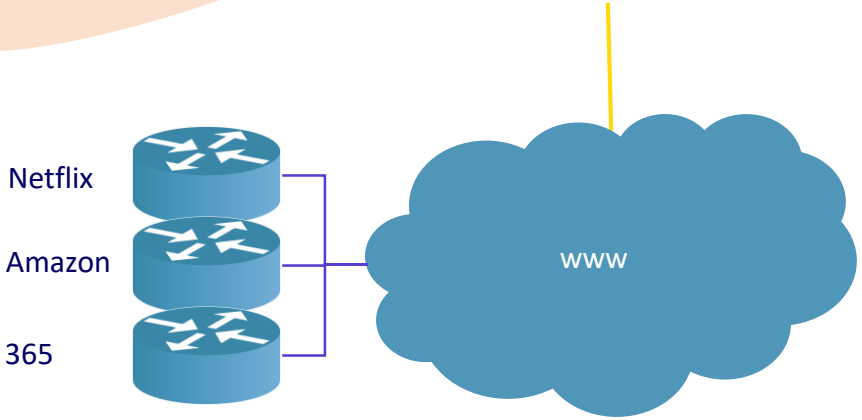
- 22 Blu Wireless 60 GHz mmWave APs around high-speed bowl
- McLaren Atlas software for real time monitoring
- Test result shows average Tput > 800 Mbps
- Phase 2 upgrade to 66-71 GHz in process

Track-to-train: 5G mmWave Solution

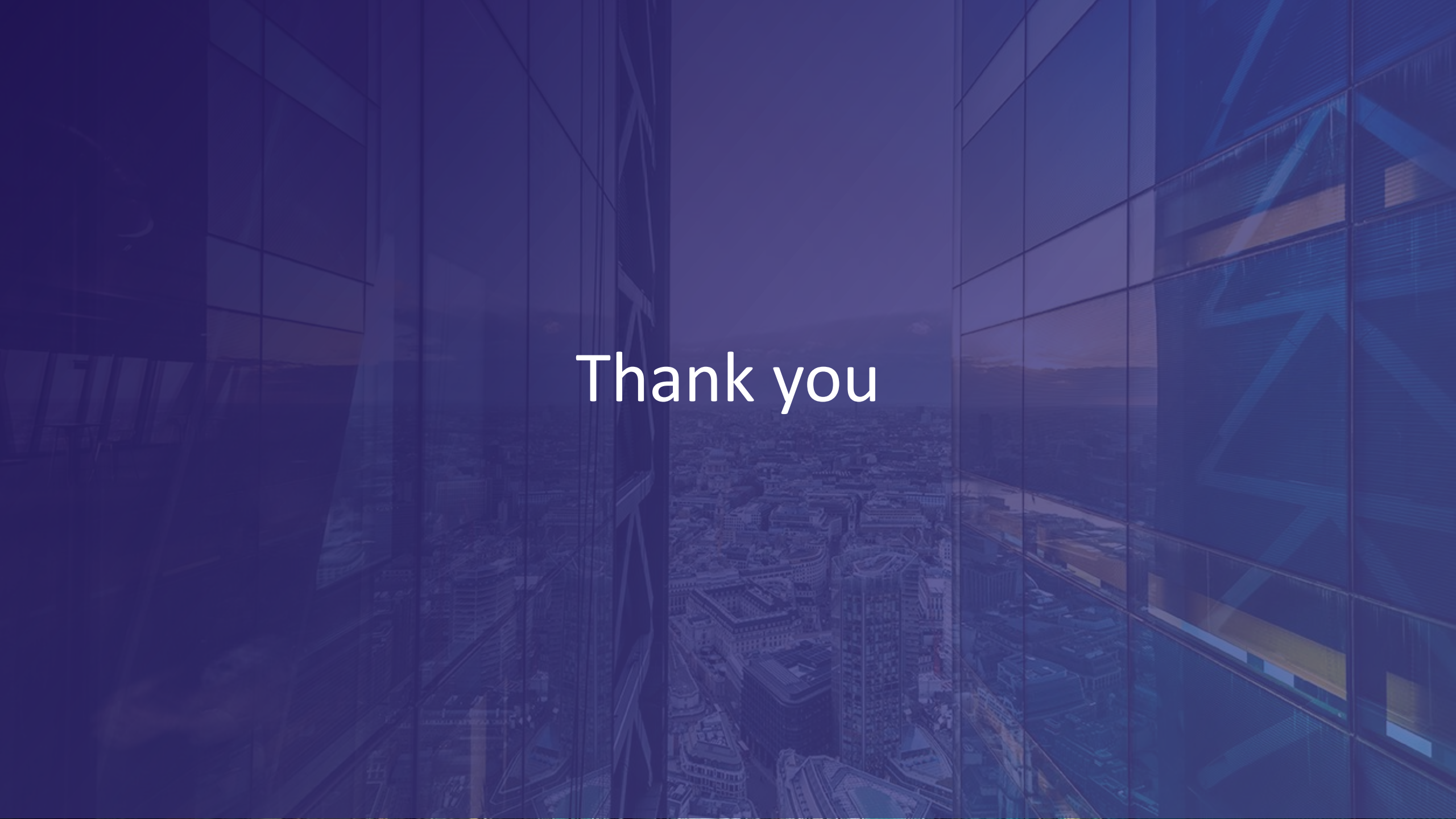


DN101 Trackside modem

TN201 Rooftop modem



- Passenger Demand for wireless to exceed 1Gbps/train by 2025
- Ofcom report to DCMS on rail connectivity, Oct ‘18 recommended use of mmWave spectrum


Thank you