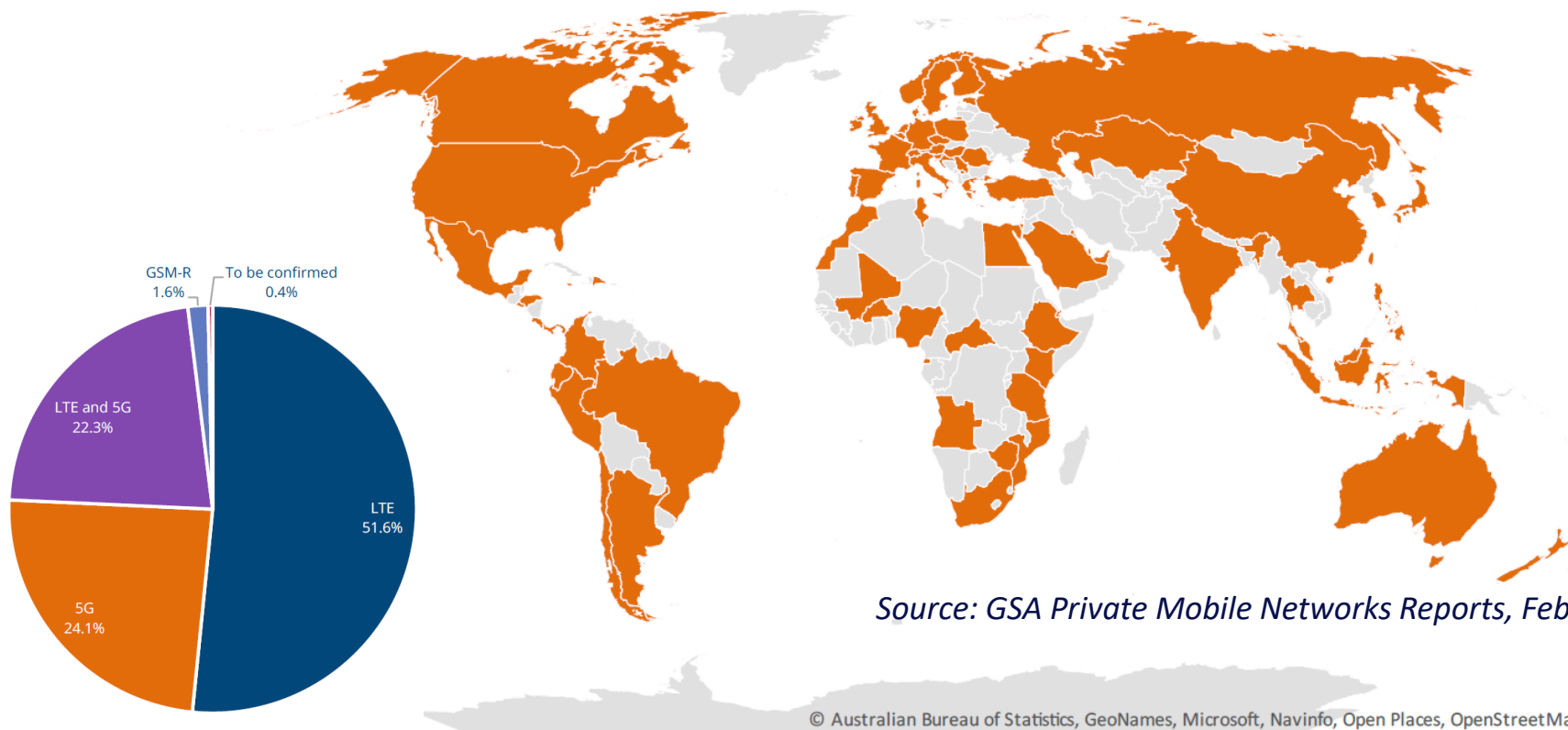# PEGATRON 和碩聯合科技 5G

5G Private Network Deployment

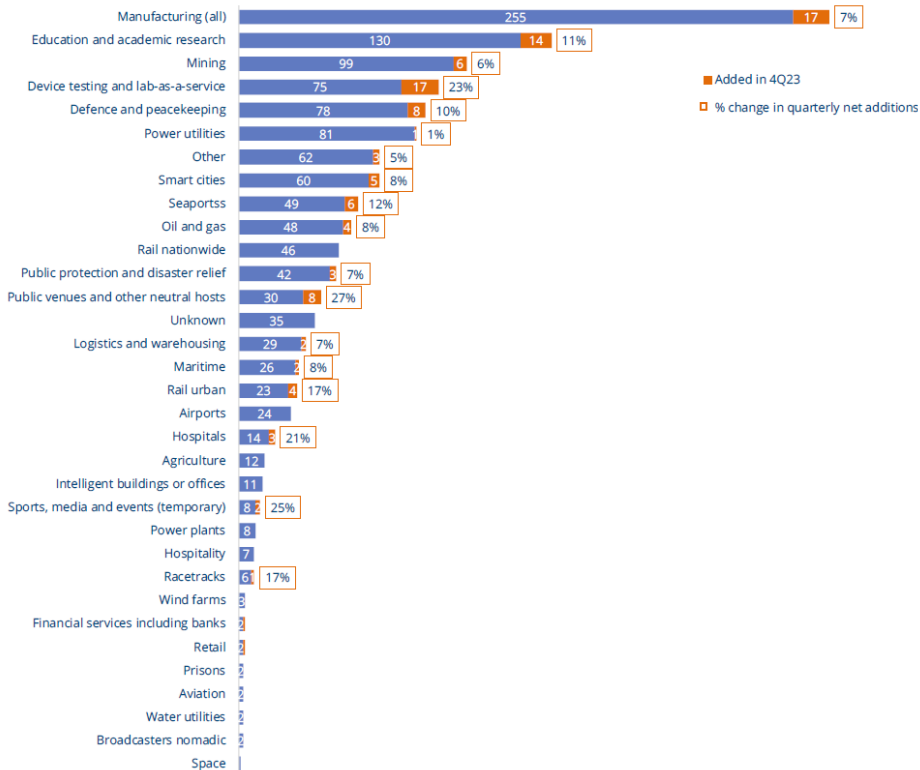May 31st, 2024

James Shue
CTO & SVP

AGENDA

- 5G Private Market

- Deployment Challenges and Requirements

- Understanding 5G Private Networks

- Technical Aspects of Deployments

- Deployment Case Studies

Countries and Territories Deploying Private Mobile Networks

Pie chart:
- LTE 51.6%
- 5G 24.1%
- LTE and 5G 22.3%
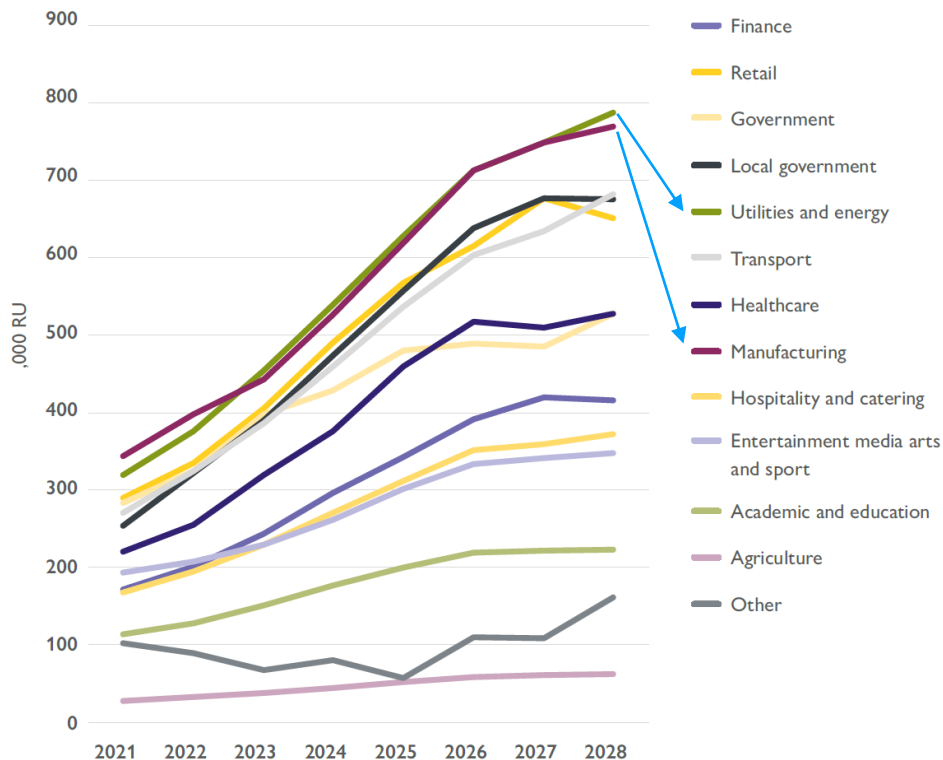- GSM-R 1.6%
- To be confirmed 0.4%

Source: GSA Private Mobile Networks Reports, Feb 2024

Powered by Bing

© Australian Bureau of Statistics, GeoNames, Microsoft, Navinfo, Open Places, OpenStreetMap, TomTom, Zenrin

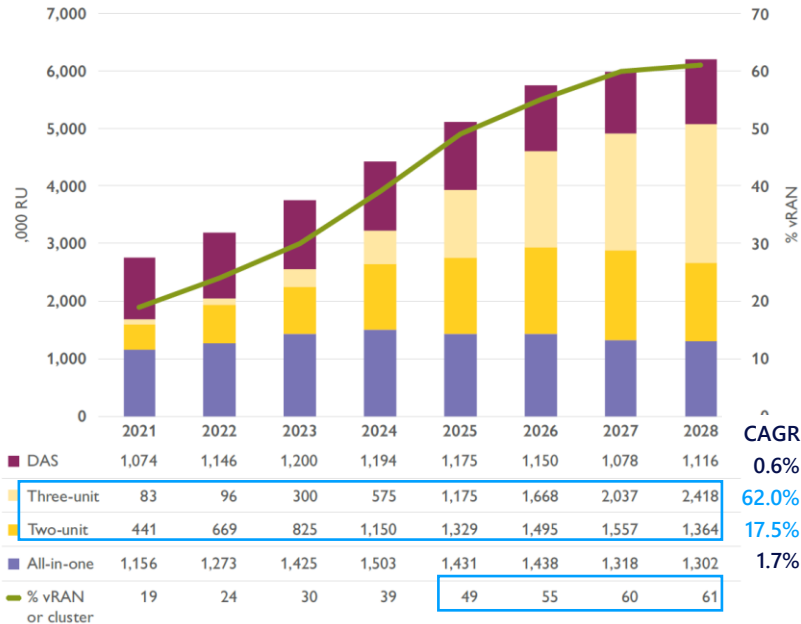# Deploying Private Networks by Sectors, and Forecast

Added in 4Q23
% change in quarterly net additions

Sector	Value	Added 4Q23	% change
Manufacturing (all)	255	17	7%
Education and academic research	130	14	11%
Mining	99	6	6%
Device testing and lab-as-a-service	75	17	23%
Defence and peacekeeping	78	8	10%
Power utilities	81	1	1%
Other	62	3	5%
Smart cities	60	5	8%
Seaportss	49	6	12%
Oil and gas	48	4	8%
Rail nationwide	46		
Public protection and disaster relief	42	3	7%
Public venues and other neutral hosts	30	8	27%
Unknown	35		
Logistics and warehousing	29	2	7%
Maritime	26	2	8%
Rail urban	23	4	17%
Airports	24		
Hospitals	14	3	21%
Agriculture	12		
Intelligent buildings or offices	11		
Sports, media and events (temporary)	8	2	25%
Power plants	8		
Hospitality	7		
Racetracks	6	1	17%
Wind farms	3		
Financial services including banks	2		
Retail	2		
Prisons	2		
Aviation	2		
Water utilities	2		
Broadcasters nomadic	2		
Space			

Source: GSA Private Mobile Networks Reports, Feb 2024

Finance
Retail
Government
Local government
Utilities and energy
Transport
Healthcare
Manufacturing
Hospitality and catering
Entertainment media arts and sport
Academic and education
Agriculture
Other

,000 RU

Source: SCF market forecast report, July 2023

Enterprise and indoor, by architecture

	2021	2022	2023	2024	2025	2026	2027	2028	CAGR
DAS	1,074	1,146	1,200	1,194	1,175	1,150	1,078	1,116	0.6%
Three-unit	83	96	300	575	1,175	1,668	2,037	2,418	62.0%
Two-unit	441	669	825	1,150	1,329	1,495	1,557	1,364	17.5%
All-in-one	1,156	1,273	1,425	1,503	1,431	1,438	1,318	1,302	1.7%
% vRAN or cluster	19	24	30	39	49	55	60	61	

Disaggregated and virtualized architecture will be the keys
vRAN and Open RAN will grow at CAGR 33%, 62% for 3-unit configuration

	2021	2022	2023	2024	2025	2026	2027	2028	CAGR
Enterprise	15	87	223	441	833	1,182	1,400	1,459	92.6%
Urban and rural	5	31	85	209	361	470	636	646	97.8%
% open RAN (of vRAN and clusters)	1	3	8	16	30	41	51	52	94.1%
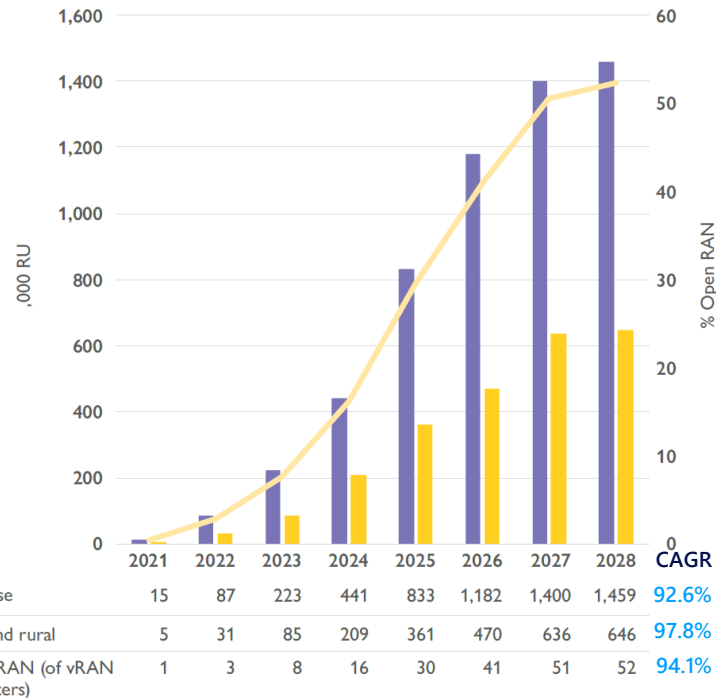
Open RAN will be high growth CAGR of 94%
Open RAN will account for 33% of vRANs or clusters in public networks, and 38% in the enterprise

Source: SCF market forecast report, July 2023

"5G, Edge and AI are Essentials to drive Digital Transformation."

"5G is the key to bridge things together."

Flexibility

- Wireless Connectivity
- Rapid Deployment

Clean

- Dedicated & Licensed Spectrum

Real-time

- Fast and Low Latency
- Low jitter

Efficiency
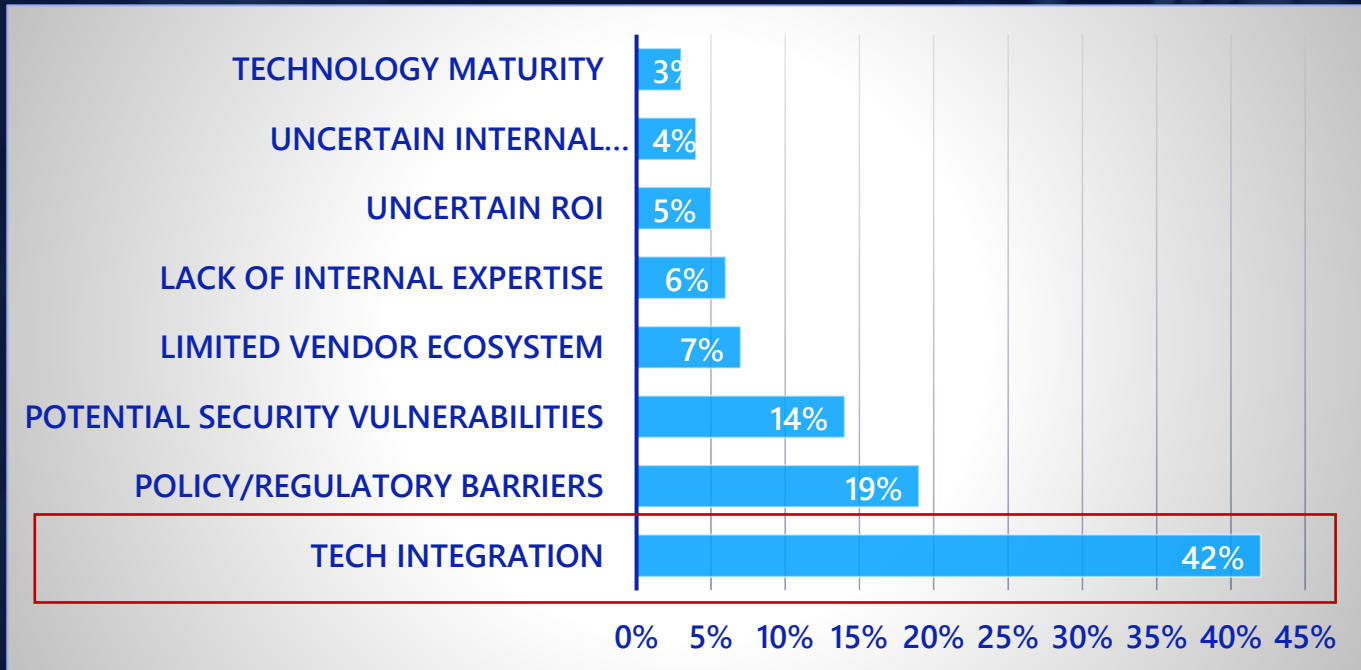
- Large Capacity
- Multi-connection
- Stable Throughput

Security

- Zero Trust
- Private and Safe

Deployment Challenges

Obstacles to deploying private wireless networks
Percentage of operators

TECHNOLOGY MATURITY — 3%
UNCERTAIN INTERNAL... — 4%
UNCERTAIN ROI — 5%
LACK OF INTERNAL EXPERTISE — 6%
LIMITED VENDOR ECOSYSTEM — 7%
POTENTIAL SECURITY VULNERABILITIES — 14%
POLICY/REGULATORY BARRIERS — 19%
TECH INTEGRATION — 42%

0% 5% 10% 15% 20% 25% 30% 35% 40% 45%

- Tech integration is the main deployment challenge
- Policy/regulation follows (spectrum?)

Source: GSMA Intelligence Operators in Focus: Network Transformation Survey, Aug 2023

What is holding private network back?

- Cost/TCO and uncertainty ROI
- Future-proofed or wrong technology
- Lock-in to a specific vendor or operator
- Complexity and lack of familiarity – comparing with Wi-Fi
- Uncertainty around use cases

Source: Cambridge Consultants: Developing private network technologies for demanding use cases, Nov 2023

Enterprise should consider:

- **Defining Key Connectivity Use Cases:**
  Drive and differentiate their business
- **Requirements Analysis:**
  Levels of complexity, bandwidth, latency, and security needs for current and future scenarios
- **Control and Automation:**
  Potential need for rapid and flexible changes to both physical operations and applications

Vendors must consider:

- **Competition with Other Solutions:**
  Public 5G networks and Wi-Fi networks
- **Meeting Requirements:**
  Existing and future requirements for latency, device density, and interoperability with other systems
- **Platform Readiness:**
  AI-enabled automation, robotics, and digital twins, etc.

5G Private Network Ecosystem

Devices

5G CPE

5G USB Dongle

5G Camera

5G Spectrum

Public Spectrum

By Telco Operators

Private Spectrum

Not limited

RAN

RU

Pegatron, Nokia, Ericsson, Huawei, Airspan, JMA Wireless, Baicells, Commscope, Benetel, NEC, Fujitsu, WNC, Lions, Foxconn, VVDN, etc.

CU/DU (BBU)

Pegatron, Nokia, Ericsson, Mavenir, Parallel Wirelss, IS-Wireless, Corning, JMA, Altiostar, Fujitsu, Dell, HTC, QCT, etc.

OAM/SMO/RIC

Pegatron, CellWize, AMDocs, GenXcomm, etc.

5GC

Cloud Based

On-Premise

Nokia, Ericsson, Cisco, Microsoft, Mavenir, Athonet, Druid, Saviah, etc.

UPF

Pegatron, Kaloom, Ericsson, Nokia

Applications

Manufacturing

Energy & Utilities

Transportation

Public Sector

Healthcare

Retails

Entertainment

Education

System Integrator

Wipro, TechMahidra, Infosys, Capgemini, Accenture, Tata Consulting, IBM, NEC, NTT Data, T-Systems, Lockheed Martin NTT Data, CTC, Sumitomo, MKI, NEC

Countries with 5G Private Spectrum/Bands: Government Policy

N48 CBRS
USA

N78 Private Spectrum
Brazil
Chile
Croatia
Czech
Denmark
Finland
France
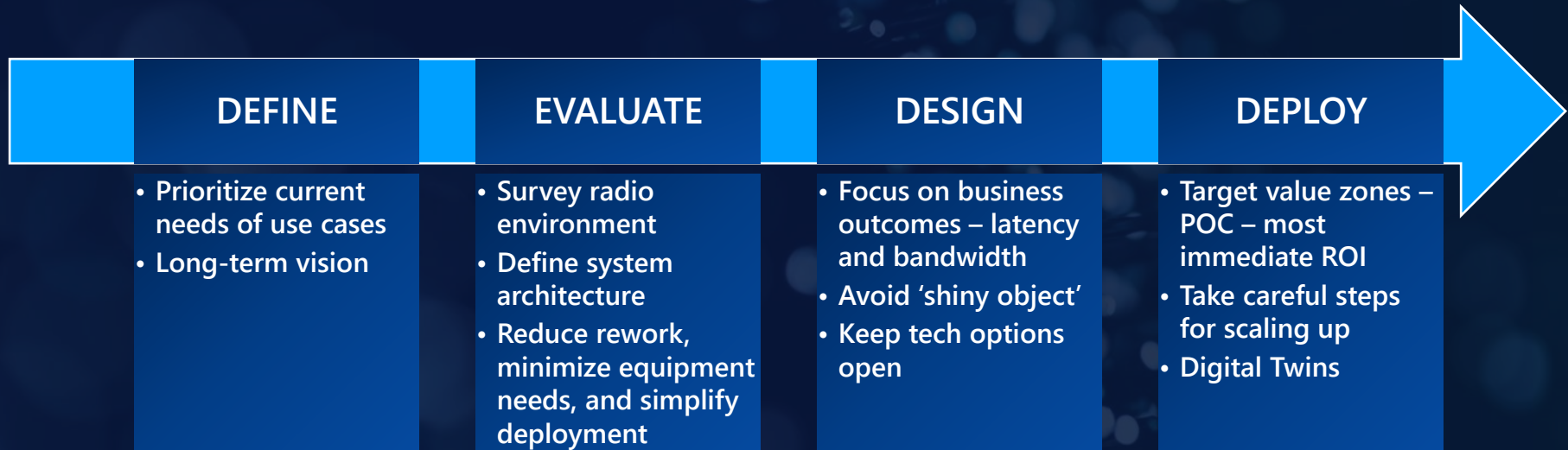Germany
Poland
Netherlands

N77 Private Spectrum
Belgium
France
Norway
Sweden
Spain
UK

N79 Private Spectrum
Japan
South Korea
Taiwan

Telco operators will use 5G public spectrum for private network if the countries without 5G private spectrum

5G Private Network Deployment Process

DEFINE	EVALUATE	DESIGN	DEPLOY
• Prioritize current needs of use cases • Long-term vision	• Survey radio environment • Define system architecture • Reduce rework, minimize equipment needs, and simplify deployment	• Focus on business outcomes – latency and bandwidth • Avoid 'shiny object' • Keep tech options open	• Target value zones – POC – most immediate ROI • Take careful steps for scaling up • Digital Twins

Use Cases: co-developed 50+ **use cases** with 5 themes around:

- Manufacturing/Automation/Logistics
- Utilities
- Transportation
- Education
- Disaster Rescue/Digital Resilience

Uses Cases - Manufacturing

- Coverage: 8400 m^2 (140m x 60m)
- Frequently change testing lines (6 mons)
- AGV should running smoothly
- AR collaboration - work around the full factory

- AI Vision for Assembly SOP
- AI Vision for surveillance and safety
- Digital Twins (cont.) – connect with various gateways and sensors to monitor networks and factory
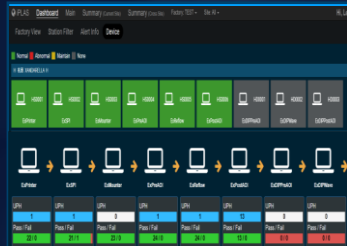
5G Dongle

Shopfloor
(Inc. Testing Station)

5G Dongle

Line Monitoring
(Smart SOP)

5G Module **5G Dongle**

AGV/AMR

BBU

Apps Servers

- SFIS server
- iPLAS server
- MEC server
- Test Log server…

5G Dongle

AR Collaboration

5G Dongle

Dashboard /Digital Twin

AOI Station Status 123

5G 4K Camera

Surveillance Camera

Confidential
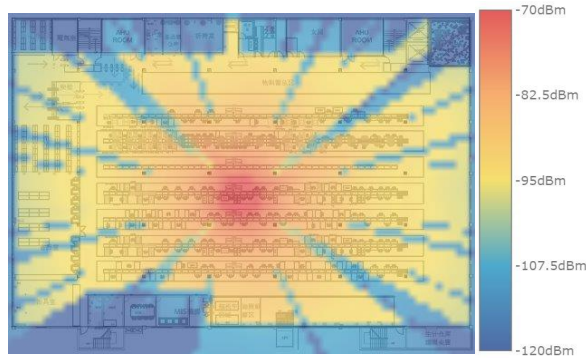
- With pre-modeling simulation, we can simulate the RSRP boundary and use SINR to estimate the maximum throughput for the applications.

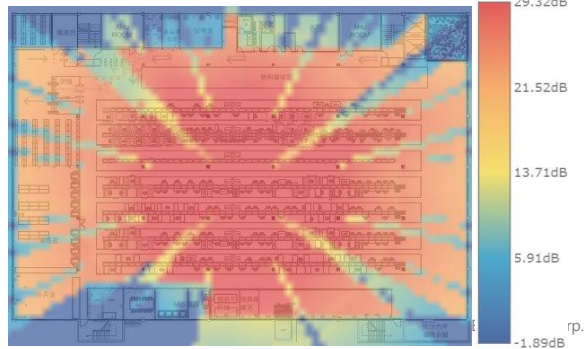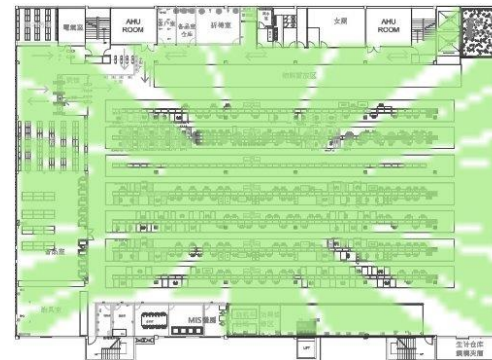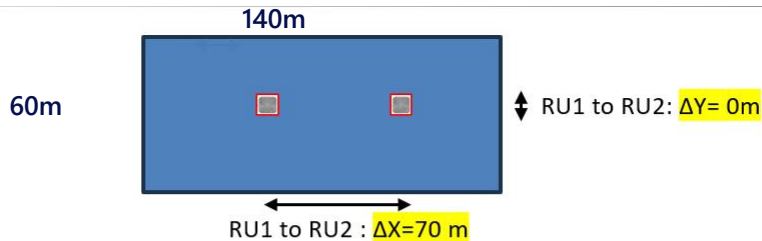### RSRP Simulation

RSRP > -95dBm area

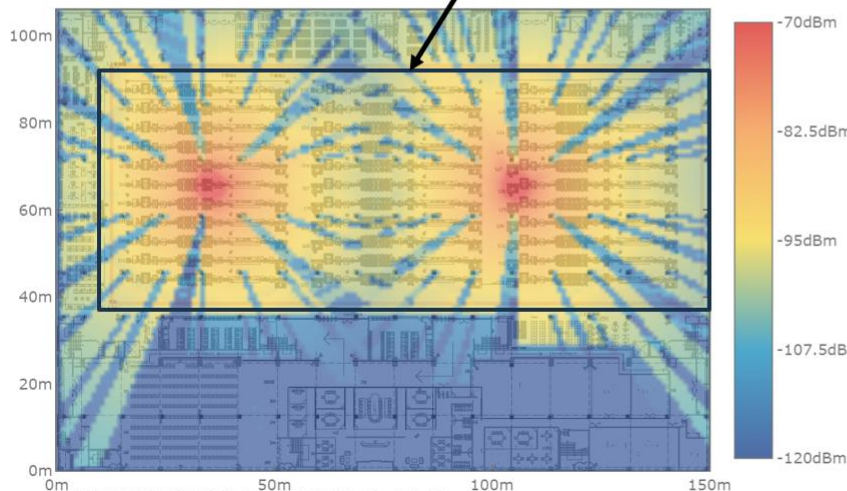### SINR Simulation

SINR > 18dB area

PEGATRON **5G**

Using 2 cells to cover 8400m² factory
With pre-modeling simulation, we
can simulate the RSRP boundary and
use SINR to estimate the maximum
throughput for the applications.

140m

60m

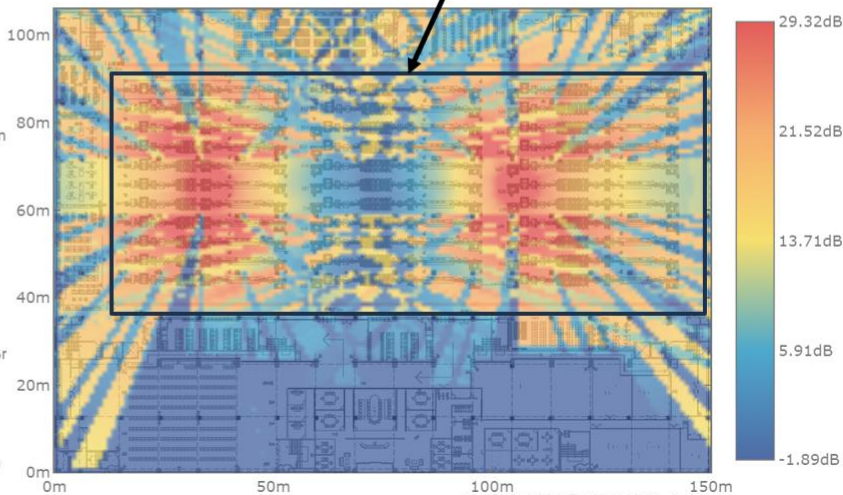RU1 to RU2: $\Delta Y = 0m$

RU1 to RU2 : $\Delta X = 70\ m$

RSRP

以RSRP>-95 dBm,計算場域覆蓋率 43%
以RSRP>-100 dBm,計算場域覆蓋率 77%

SINR

SINR>10dB,計算場域覆蓋率 66%
SINR>5dB,計算場域覆蓋率 84%

PEGATRON 和碩聯合科技

CONFIDENTIAL

F=3450MHz,SCS=30KHz, BW=100MHz,RU output power=24dBm
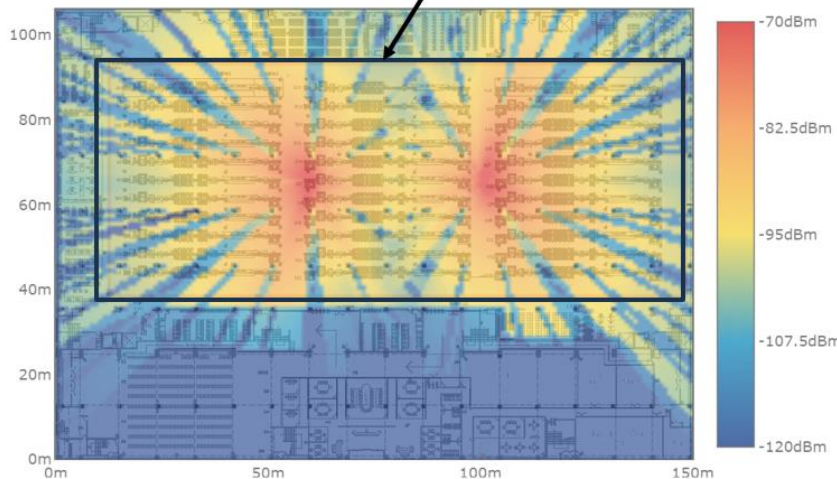
Using different RU mounting

RU1 to RU2: ΔY= 0m

RU1 to RU2 : ΔX=40 m
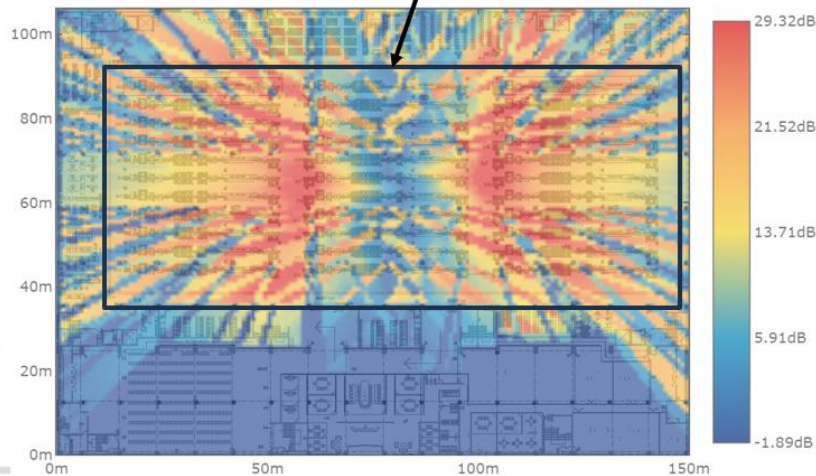
RSRP — 以RSRP>-95 dBm,計算場域覆蓋率 52%
以RSRP>-100 dBm,計算場域覆蓋率 77%

SINR — SINR>10dB,計算場域覆蓋率71%
SINR>5dB,計算場域覆蓋率 85%

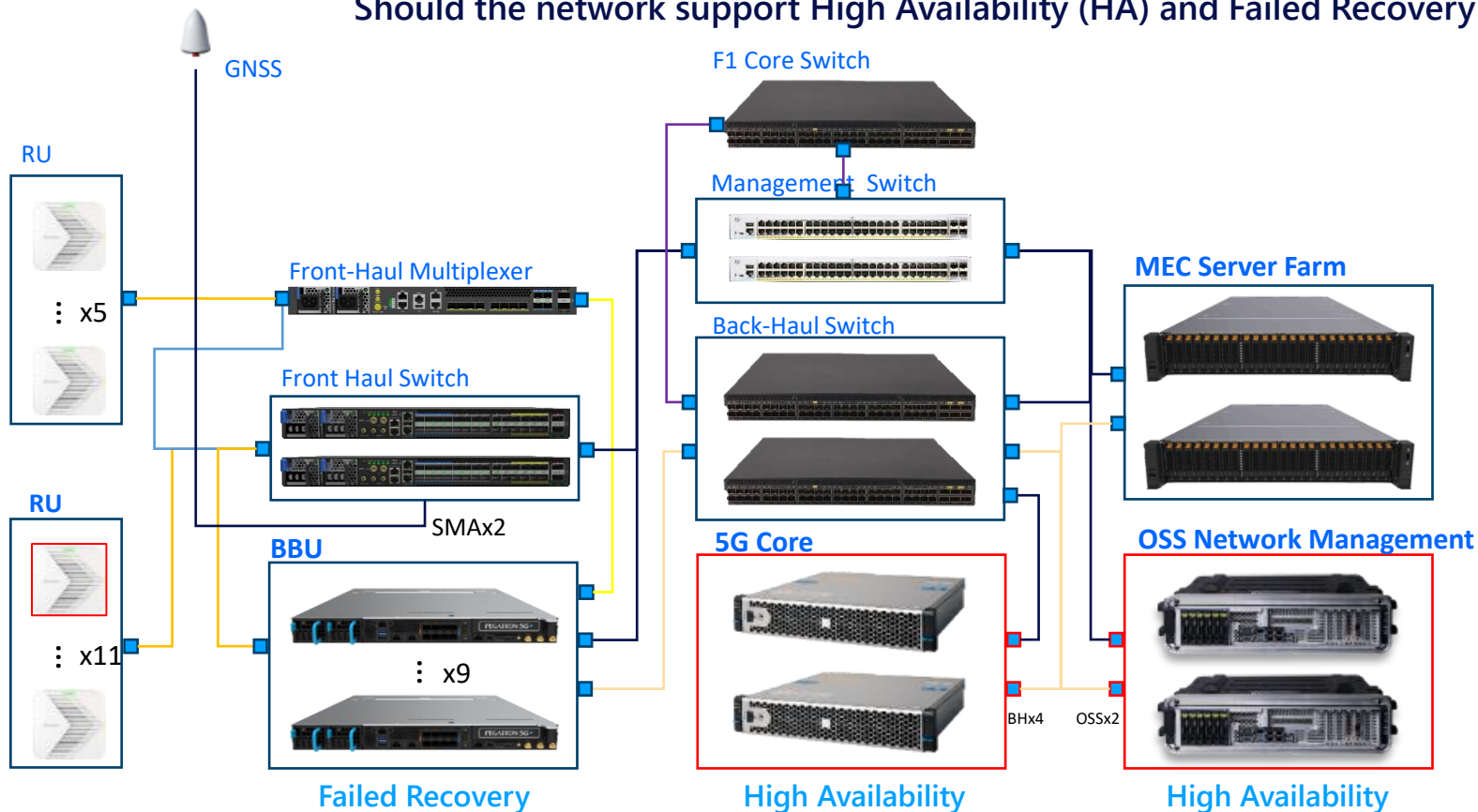F=3450MHz,SCS=30KHz, BW=100MHz，RU output power=24dBm

Row 1, Left:
RSRP>-95dBm, 43% SINR>10dB, 66%
RSRP>-100dBm, 77% SINR>5dB, 84%
RU1 to RU2: ΔY= 0m
RU1 to RU2 : ΔX=70 m

Row 1, Center:
RSRP>-95dBm, 22% SINR>10dB, 57%
RSRP>-100dBm, 43% SINR>5dB, 73%
RU1 to RU2: ΔY= 0m
RU1 to RU2 : ΔX=135 m

Row 1, Right:
RSRP>-95dBm, 22% SINR>10dB, 57%
RSRP>-100dBm, 44% SINR>5dB, 73%
RU1 to RU2: ΔY= 0m
RU1 to RU2 : ΔX=135 m

Row 2, Left:
RSRP>-95dBm, 48% SINR>10dB, 58%
RSRP>-100dBm, 69% SINR>5dB, 78%
RU1 to RU2: ΔY= 0m
RU1 to RU2 : ΔX=20 m

Row 2, Center:
RSRP>-95dBm, 52% SINR>10dB, 71%
RSRP>-100dBm, 77% SINR>5dB, 85%
RU1 to RU2: ΔY= 0m
RU1 to RU2 : ΔX=40 m

Row 2, Right:
RSRP>-95dBm, 23% SINR>10dB, 60%
RSRP>-100dBm, 50% SINR>5dB, 78%
RU1 to RU2: ΔY= 55m
RU1 to RU2 : ΔX=135 m

Row 3, Left:
20m
RSRP>-95dBm, 22% SINR>10dB, 58%
RSRP>-100dBm, 41% SINR>5dB, 76%
RU1 to RU2 : ΔY=55m
20m
RU1 to RU2 : ΔX=95 m

Row 3, Center:
20m
15°
RSRP>-95dBm, 31% SINR>10dB, 64%
RSRP>-100dBm, 47% SINR>5dB, 80%
RU1 to RU2 : ΔY=55m
15°
20m
RU1 to RU2 : ΔX=95 m

Row 3, Right:
20m
RSRP>-95dBm, 31% SINR>10dB, 59%
RSRP>-100dBm, 60% SINR>5dB, 82%
20m
RU1 to RU2: ΔY= 55m
RU1 to RU2 : ΔX=95 m

Row 4, Left:
RSRP>-95dBm, 55% SINR>10dB, 67%
RSRP>-100dBm, 74% SINR>5dB, 84%
RU1 to RU2: ΔY= 0m
RU1 to RU2 : ΔX=40 m

Row 4, Center:
RSRP>-95dBm, 55% SINR>10dB, 67%
RSRP>-100dBm, 72% SINR>5dB, 84%
RU1 to RU2: ΔY= 55m
RU1 to RU2 : ΔX=30 m

Row 4, Right:
RSRP>-95dBm, 13% SINR>10dB, 4%
RSRP>-100dBm, 27% SINR>5dB, 24%
RU1 to RU2: ΔY= 0m
RU1 to RU2 : ΔX=0.5 m

PEGATRON 5G

Should the network support High Availability (HA) and Failed Recovery?

GNSS

F1 Core Switch

Management Switch

RU

Front-Haul Multiplexer

MEC Server Farm

Front Haul Switch

Back-Haul Switch

RU

SMAx2

x5

BBU

5G Core

OSS Network Management

x11

x9

BHx4 OSSx2

Failed Recovery

High Availability

High Availability

5G is Driving Industrial Transformation

EDGE
High Performance Computing
PEGATRON SVR

Products and
Manufacturing

Next-Gen Communication
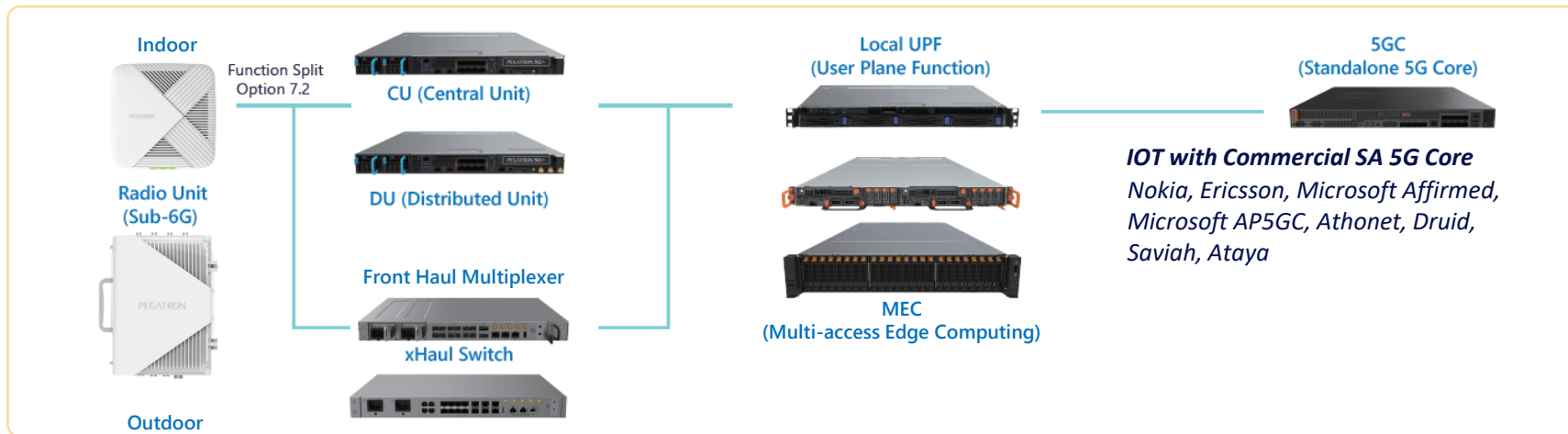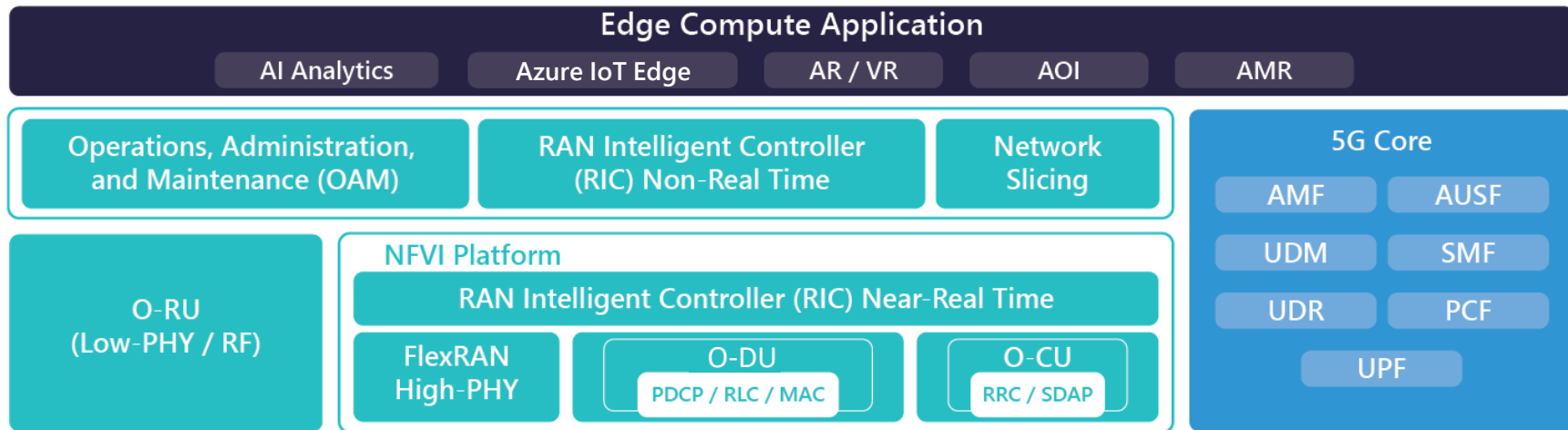PEGATRON 5G
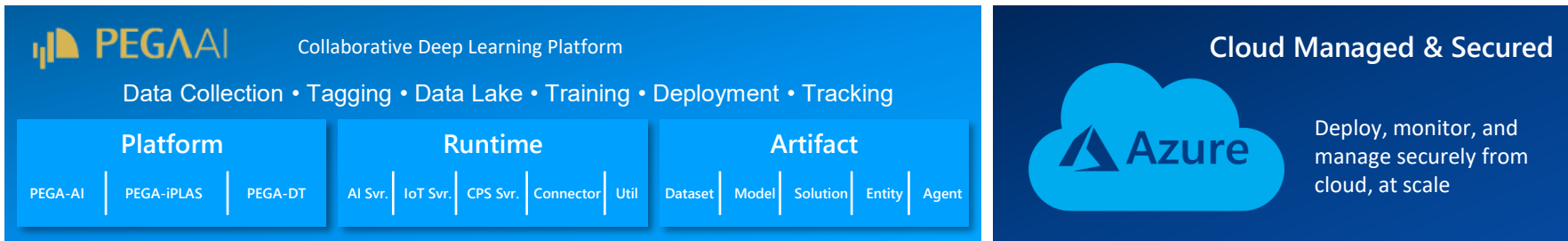
Digital
Transformation

AI
Accelerated Computing
PEGAAI

Edge Compute Application

AI Analytics	Azure IoT Edge	AR / VR	AOI	AMR

Operations, Administration, and Maintenance (OAM)

RAN Intelligent Controller (RIC) Non-Real Time

Network Slicing

5G Core

AMF	AUSF
UDM	SMF
UDR	PCF
UPF	

O-RU (Low-PHY / RF)

NFVI Platform

RAN Intelligent Controller (RIC) Near-Real Time

FlexRAN High-PHY

O-DU
PDCP / RLC / MAC

O-CU
RRC / SDAP

Indoor

Function Split Option 7.2

CU (Central Unit)

DU (Distributed Unit)

Radio Unit (Sub-6G)

Front Haul Multiplexer

xHaul Switch

Outdoor

Local UPF (User Plane Function)

5GC (Standalone 5G Core)

IOT with Commercial SA 5G Core
Nokia, Ericsson, Microsoft Affirmed, Microsoft AP5GC, Athonet, Druid, Saviah, Ataya

MEC (Multi-access Edge Computing)

How to choose?
Who can help us to integrate everything?

Application

Automation	AI and Video Analytics	IOT and Digital Twins	Remote Assistance	Others

Automation

Robot Control · AGV/AMR

AI and Video Analytics

AOI · SOP · Security & Safety

IOT and Digital Twins

Smart Energy · Equipment Intelligent · Digital Twins

Remote Assistance

360 Camera · AR Remote Collaboration

Platform

PEGAAI — Collaborative Deep Learning Platform

Data Collection • Tagging • Data Lake • Training • Deployment • Tracking

Platform	Runtime	Artifact
PEGA-AI · PEGA-iPLAS · PEGA-DT	AI Svr. · IoT Svr. · CPS Svr. · Connector · Util	Dataset · Model · Solution · Entity · Agent

Cloud Managed & Secured

Azure

Deploy, monitor, and manage securely from cloud, at scale

Infrastructure

Communication

- Indoor RU
- 5G BBU
- Outdoor RU
- xHaul Switch

Computing

- Edge Server
- High Performance Server
- AI & Storage Server

Devices

- 5G CPE
- 5G Dongle
- 5G Camera
- VR
- AR
- Wearable

Partner Devices

- Robot Arm
- Smart Radio
- MR
- AGV/AMR
- IOT Gateways

Rapid Deployment

Vision AI

Assembly Monitoring
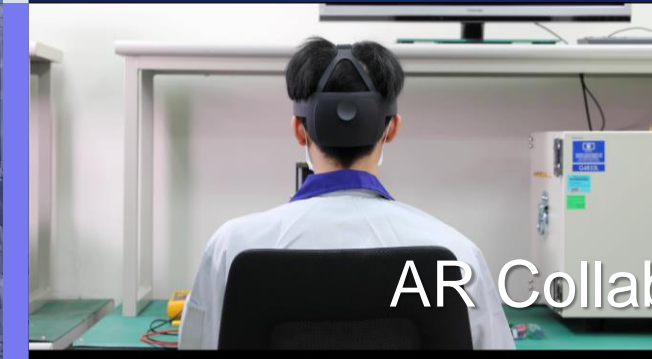
AR Collaboration

PEGATRON 5G

5G Smart Factory Deployment

5G Private Network Worldwide Experience

Smart Manufacturing

Digital Resilience

Education & Healthcare

Utilities & Energy

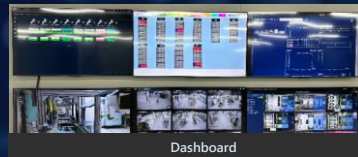Transportation & Maritime

Campus & Exhibition Center

Poland

Japan

Taiwan

Vietnam

Indonesia

US

5G Smart Factory in **Taoyuan**

SFIS / Line Monitor

SFIS / Digital Twins

SFIS / Digital Twins

Dashboard

Server Room

Pre-Assembly Area

Board Level Function Test Area

SMT Production Line

DIP Production Line

L6 and L10 Assembly and Testing Line

L6 and L10 Packing Line

L10 Aging Room

L11 Aging Room

Dashboard

SFIS

SFIS / Digital Twin / Line Monitor

AMR

SFIS / Digital Twin / AMR
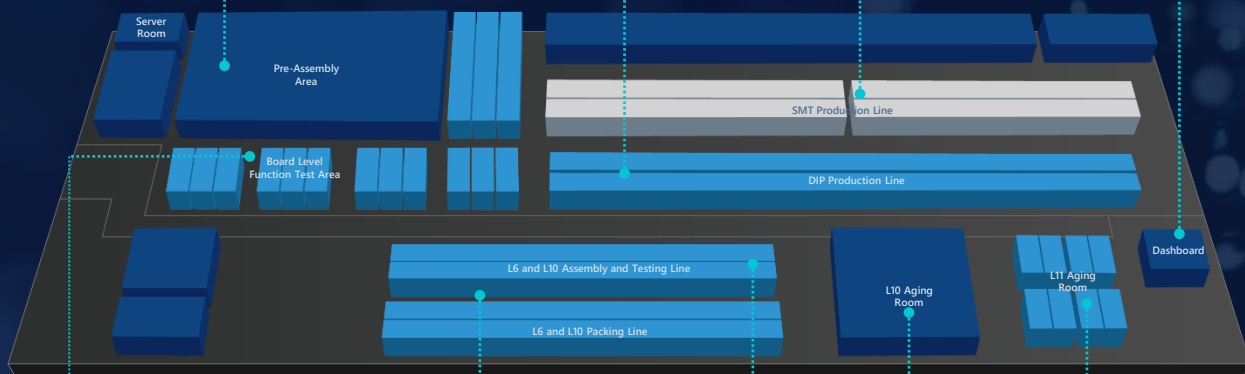
SFIS

Devices Connection :

> 120
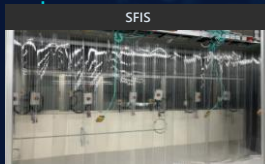
Signal Coverage :

>2,000㎡

5G Smart Factory in **Vietnam**

PEGATRON 5G
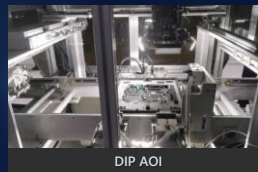
DIP AOI

SFIS / Line Monitor

SFIS / AI SOP

AGV

RU

RU

RU

RU

RU

RU

SMT Line

DIP

MLB

Packing Line

FATP

Material WH

Aging Room

Material WH

IQC

Product WH

SFIS / Dashboard

Remote Collaboration : AR

AI Surveillance

AI Face
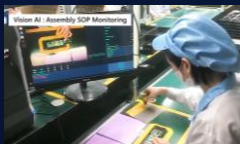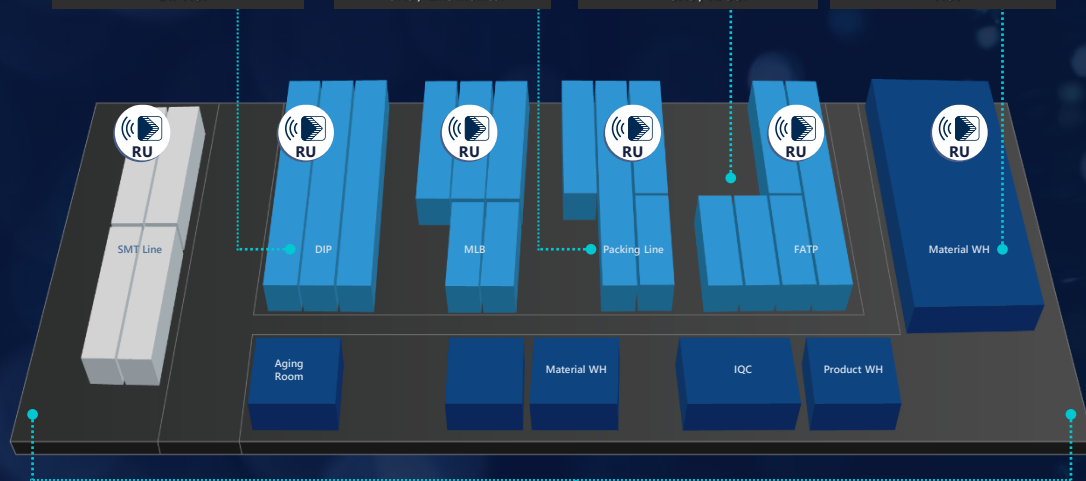
Devices Connection :

> 500+

Signal Coverage :

>12,000 ㎡
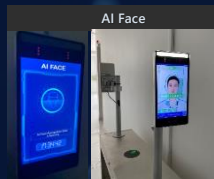
5G Smart Factory in **Indonesia**

PEGATRON 5G

Test 100% · Label Sticking · Auto Screw · Unit AOI · Box Folding · Box Cover · Unit Weight · Packing · Accessory · Carton Label · PCBA AOI

FATP
11 items

RU · RU · RU · RU

PCBA Warehouse
3 items

Stack AGV
Tray Recycle
PCBA Shelf

Carrier Recycle
DIP AOI
Auto Insertion
Input
Auto Carrier

FATP 32

Package Material WH
Assy Material WH
PCBA WH

RU · RU · RU · RU

DIP
5 items

FATP 18

DIP 12

SMT WH
Package Material WH
Assy Material WH
PCBA WH

SMT Warehouse
3 items

Material AMR
Smart Material
Smart Material

Auto Pick
Part Connect
Carrier Recycle
Label Sticking

RU · RU · RU · RU

SMT
4 items

SMT 33

SMT Material WH
FG WH C
FG WH B
FG WH A

FG Warehouse
4 items

Auto Weight
AGV
Auto Pack
Pallet Stack

Devices Connection :

> **1,000+**

Signal Coverage :

> **85,000㎡**

Advancing to Next Level Comprehensive 5G integration

More Edge and AI Applications :

- Digital Twins

- Intelligent AMR/AGV

- AI security system

- Massive and numerous devices
  connection capacity

Taiwan

Vietnam

Indonesia

2022   *2023*   *2024*

Thanks

PEGATRON 5G
和碩聯合科技

5G ORAN Brochure

5G User Equipment