Building an end-to-end 5G India Test Bed - A collaborative project
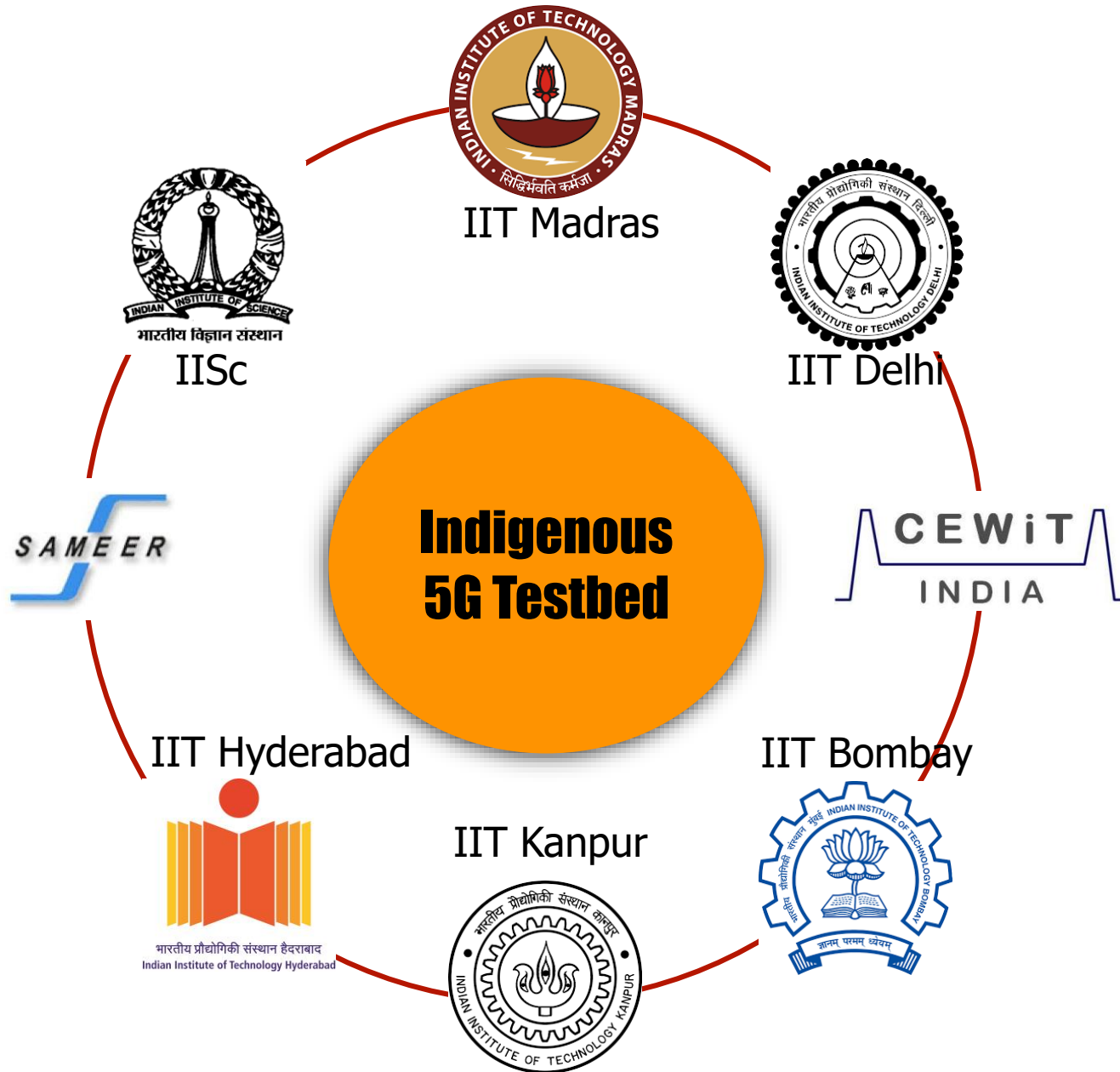
February   2020

Development of an Indigenous End-to-end 5G Test Bed

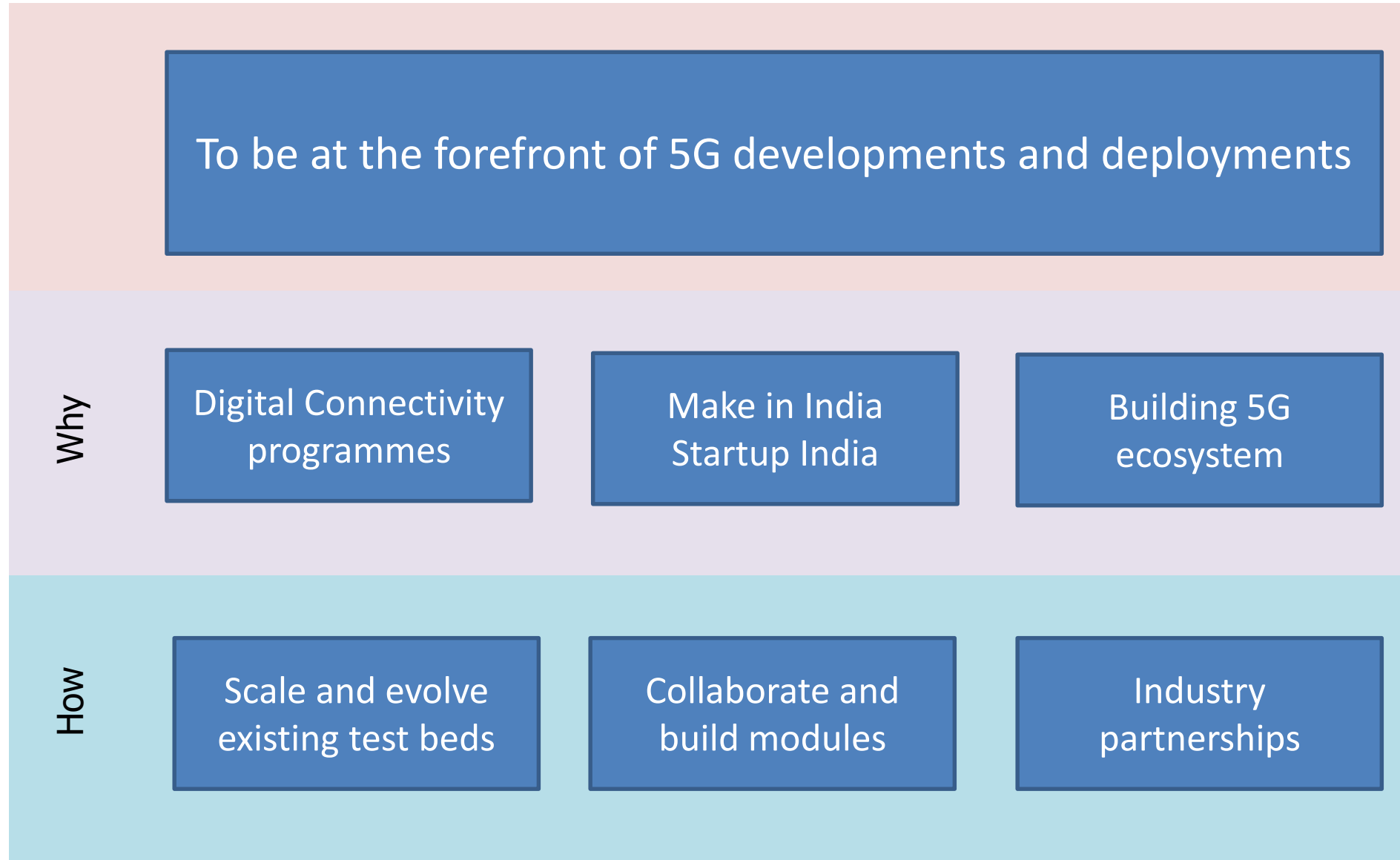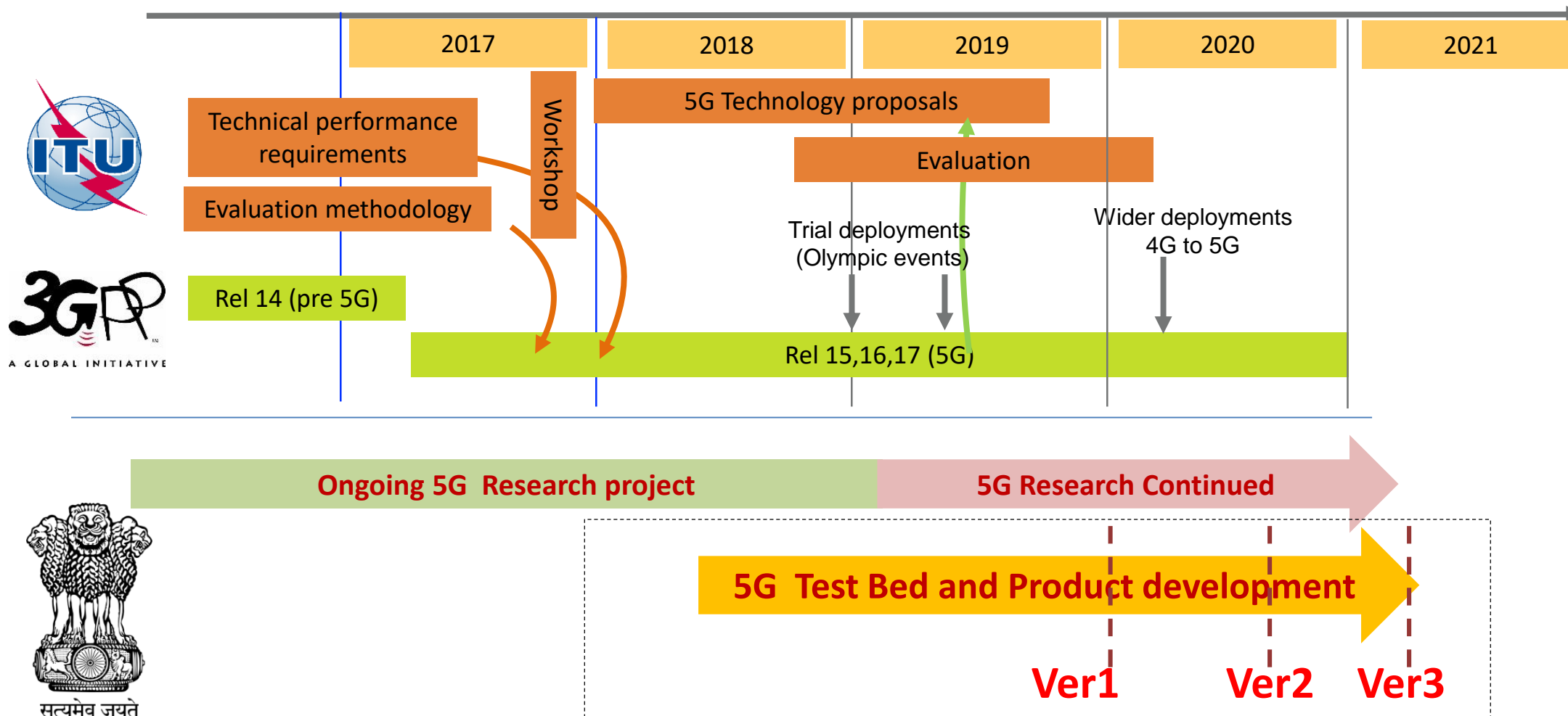Supported By

Department of Telecommunications
Ministry of Communications
Government of India

5G India Test Bed – Background and Goals

5G Test Bed in India, by India

CEWiT INDIA

To be at the forefront of 5G developments and deployments

Why

| Digital Connectivity programmes | Make in India Startup India | Building 5G ecosystem |

How

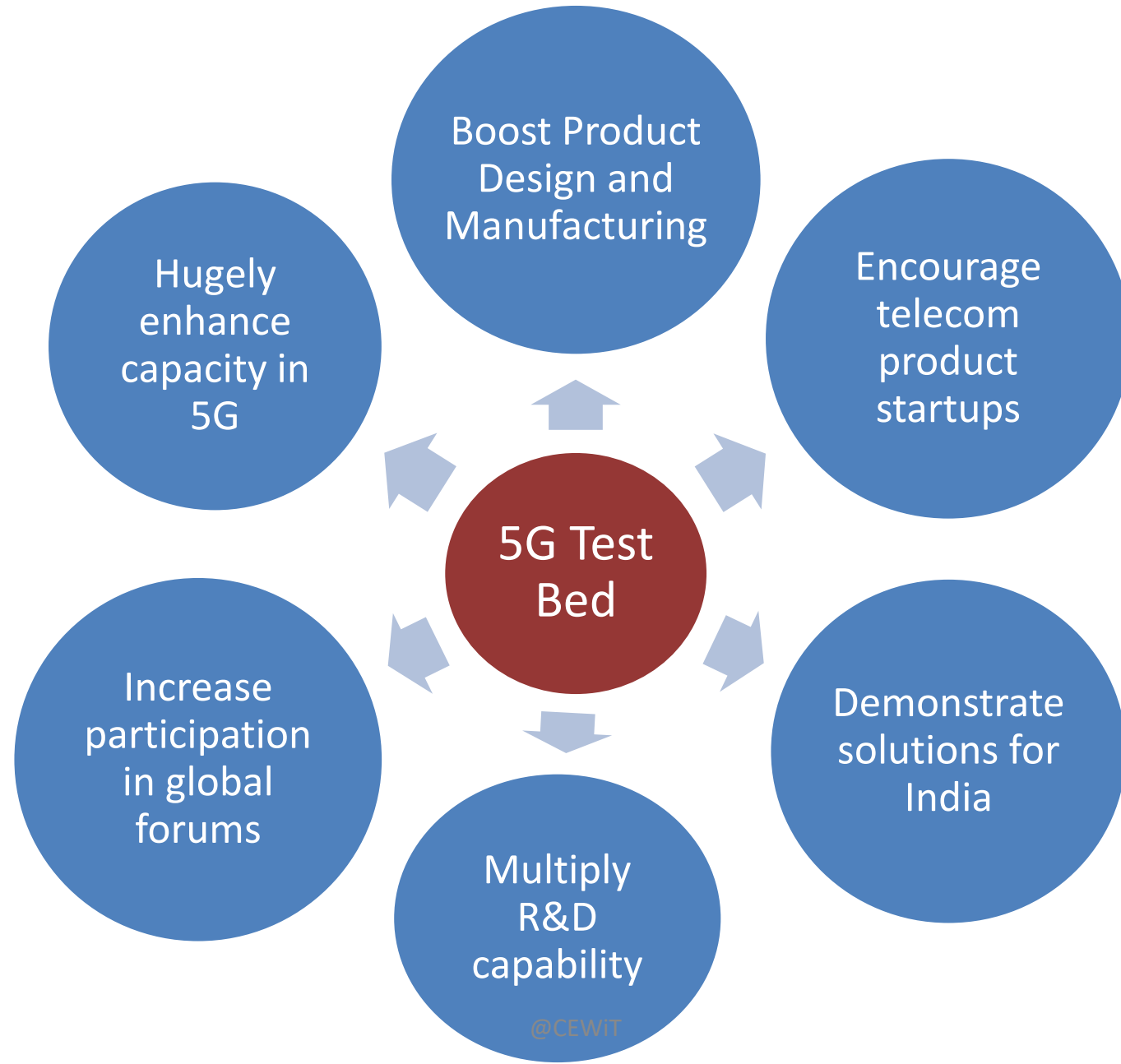| Scale and evolve existing test beds | Collaborate and build modules | Industry partnerships |

Aligned with Global and National plans

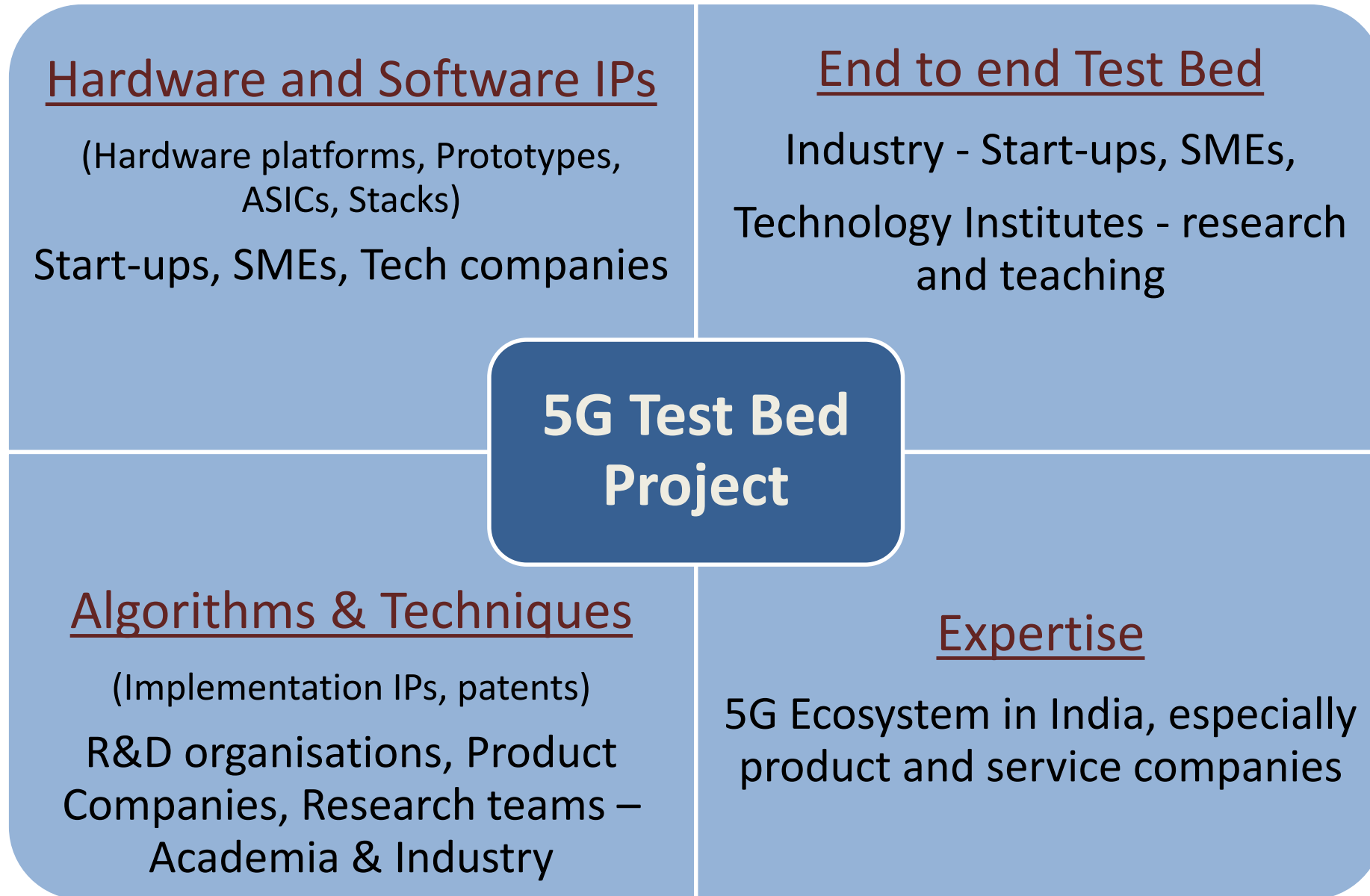
Duration of 5G test Bed development project – Apr 2018 to Mar 2021

Major Goals of 5G test bed

Boost Product Design and Manufacturing

Encourage telecom product startups

Hugely enhance capacity in 5G

5G Test Bed

Demonstrate solutions for India

Increase participation in global forums

Multiply R&D capability

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Test Bed Outcomes and their uses

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Hardware and Software IPs

(Hardware platforms, Prototypes, ASICs, Stacks)

Start-ups, SMEs, Tech companies

End to end Test Bed

Industry - Start-ups, SMEs,

Technology Institutes - research and teaching

5G Test Bed Project

Algorithms & Techniques

(Implementation IPs, patents)

R&D organisations, Product Companies, Research teams – Academia & Industry

Expertise

5G Ecosystem in India, especially product and service companies
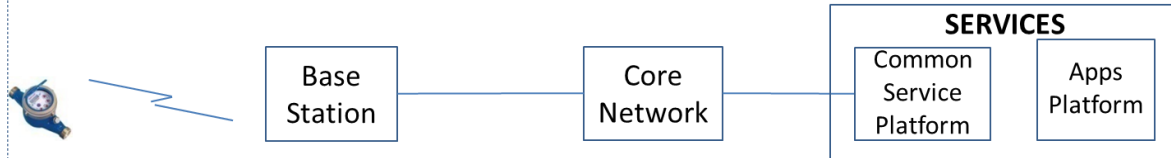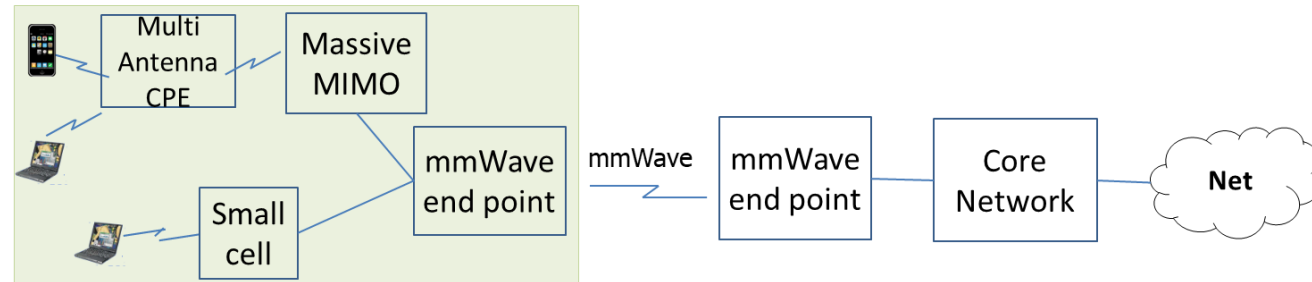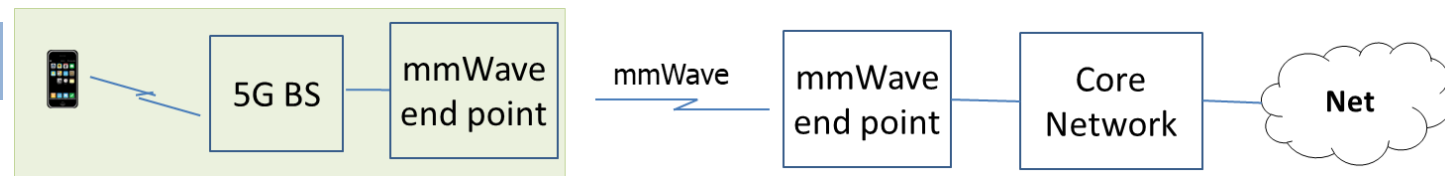
Typical Use Cases

LMLC (Low Mobility large Cell) – Rural coverage

Dense Urban

Internet Of Things

Rural backhaul

5G Test Bed Team

Collaborating Institutes

Institute
CEWiT
IIT Bombay
IIT Delhi
IIT Hyderabad
IIT Madras
IIT Kanpur
IISc Bangalore
SAMEER

❑ More than 50 Investigators (faculty members/Senior researchers)

❑ More than 250 engineers

5G Test Bed Setup

5G Test Bed Planned in these Locations

IITD, Delhi
IITK, Kanpur
IITB, Mumbai
IITH, Hyderabad
IISc, Bangalore
IITM/CEWiT, Chennai
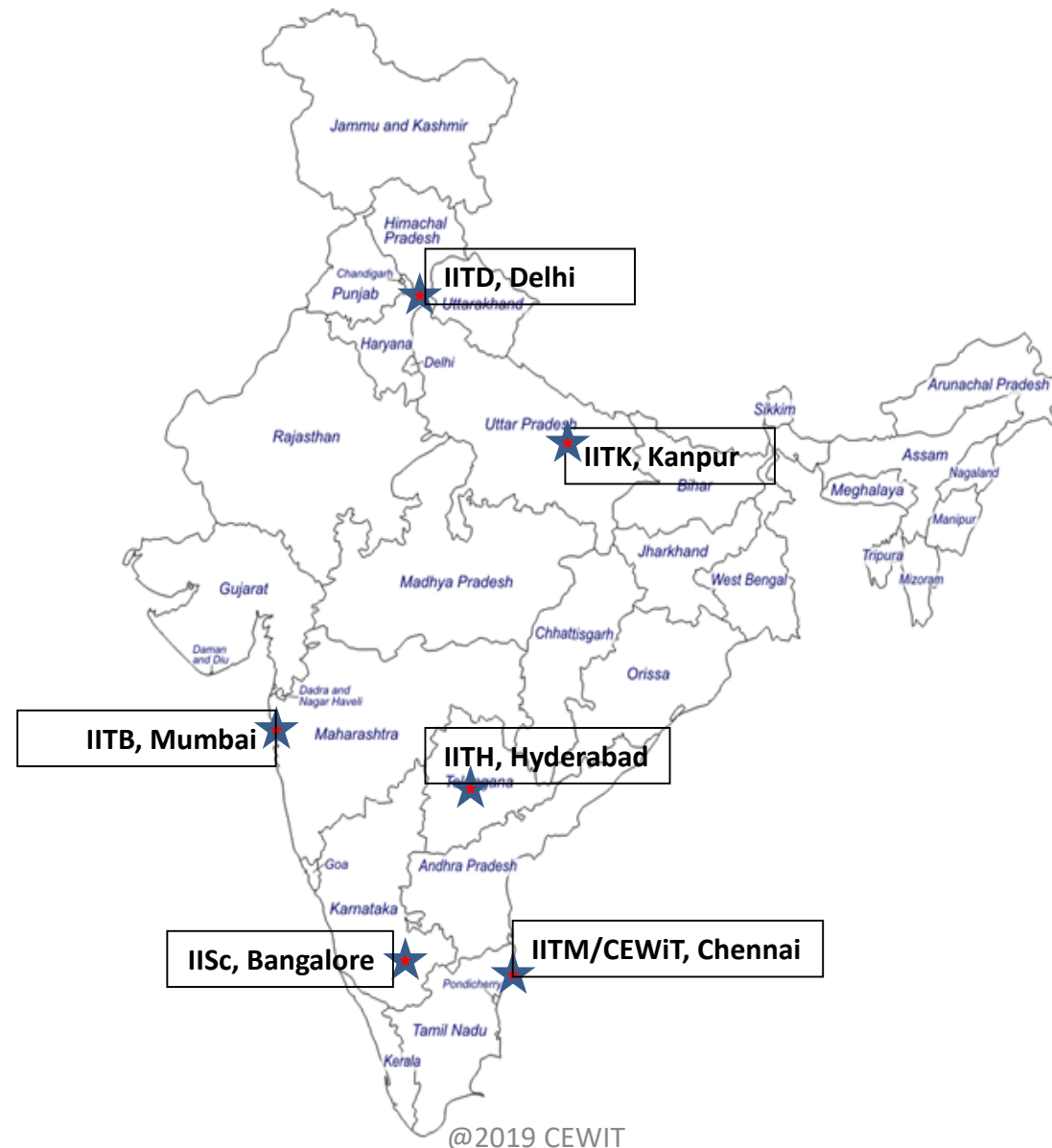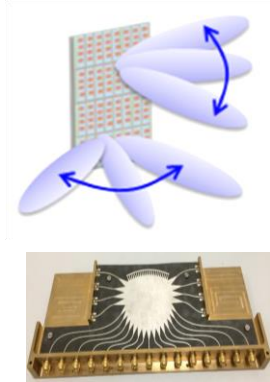
RAN components

Antenna systems
for mmWave and
Massive MIMO
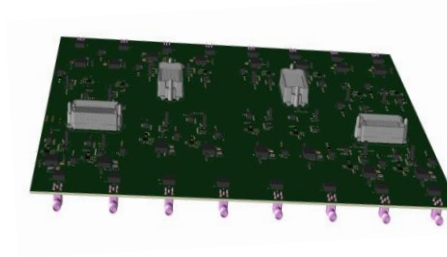
**Remote
Radio Head**
for mmWave
and Massive
MIMO

Base band
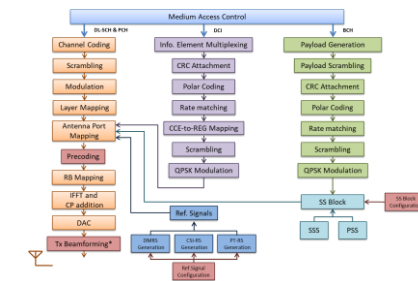
**Layer 1
(PHY)**

NB-IOT

**Layer2 &
Layer3**
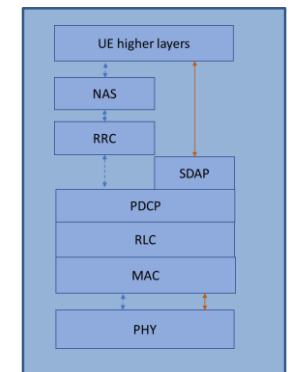
UE

Core, Management and Others
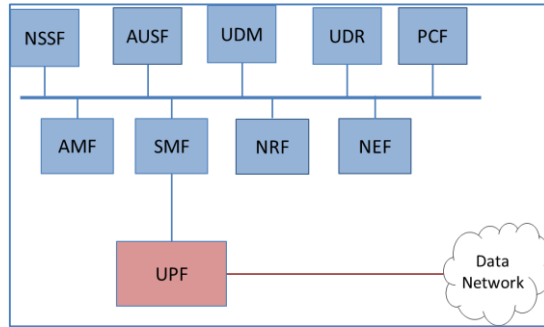
5G Core
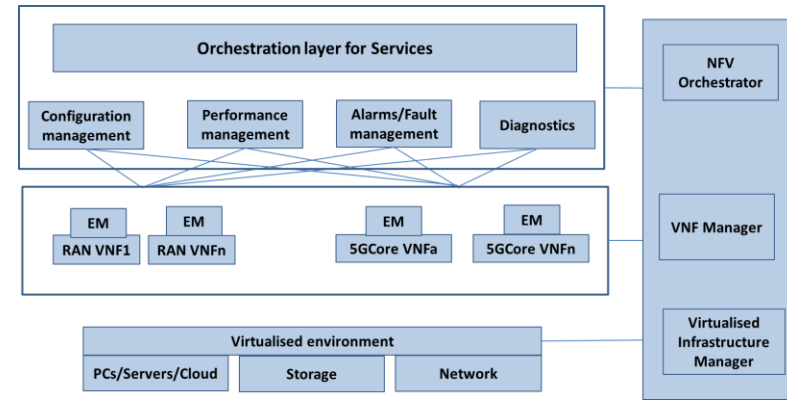
Management and Orchestration

Security

VLC / LiFi
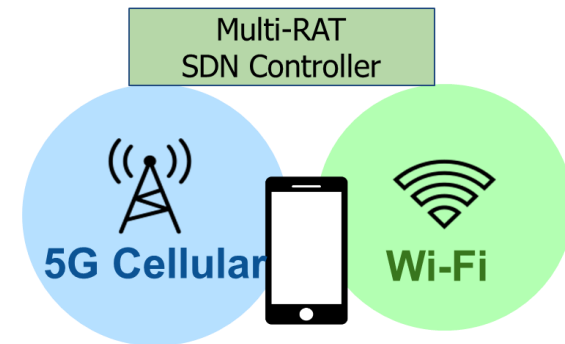
Multi-RAT

Components of the End-to-end 5G Test Bed

CEWiT
INDIA

Test Equipments

Management and Orchestration layer

User Device

UE higher layers
NAS
RRC
SDAP
PDCP
RLC
MAC
PHY

NR

gNodeB

Antenna

RRH

Base Band

Server

Sub 6 GHZ

mmWave

eCPRI

L2/L3

L1

5G Core

Control Plane Functions

User Plane Function

External AF

External Network

Non-3GPP (WiFi)

N3IWF

RAN Emulator
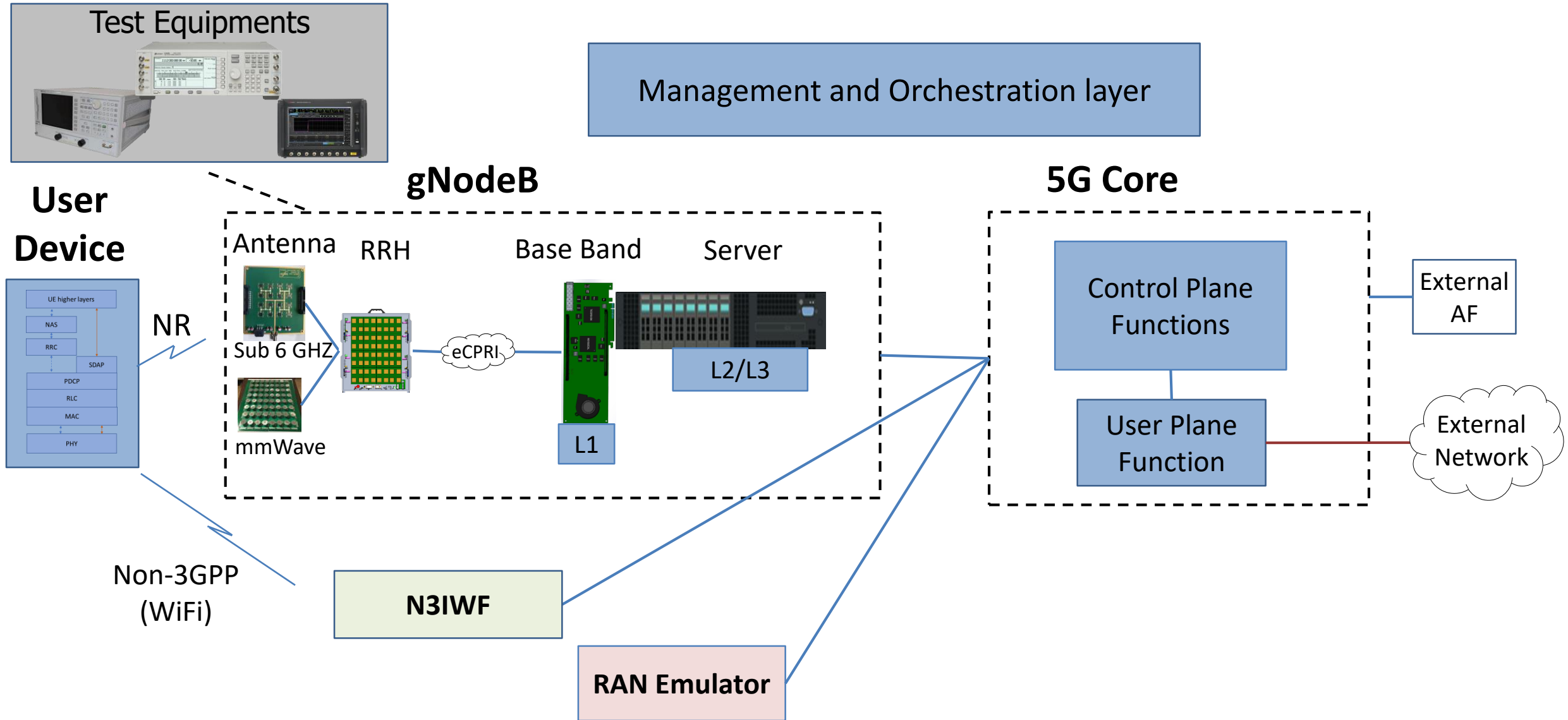
IoT based Air Pollution Monitoring System

Applications
- **Smart City development**
- **National Air Monitoring Networks**
- **Airport Monitoring**

Connectivity

GSM · NB-IoT · WiFi
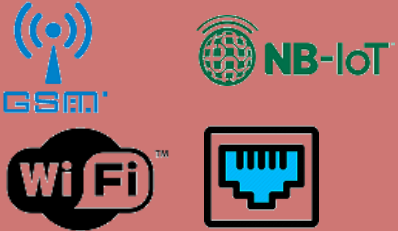
Pollutants
PM2.5, PM10, CO2, CO, O3,Temp,RH

Other Features
- **Data Rate:375 Kbps (Max UL/DL)**
- **MQTT Protocol Support**
- **Public/private/hybrid cloud support**

Real Time Update

Mobile App

AEROCITY
PM 2.5   PM 10
50   160
AQI
270
AIR QUALITY IS GOOD
51.40   27.70

Prediction using AI/ML

Live
Predicted

*

* Reference Picture Only

Li-Fi setup

Block diagram

Modulated data → LED driver circuit → Lens → Optical wireless channel → Lens → Amplification & Processing → Demodulated data

Designed LiFi Modules

Transmitter

Receiver

LiFi link setup

Transmitter

Receiver

VLC set-up and real-time experiments with USRP
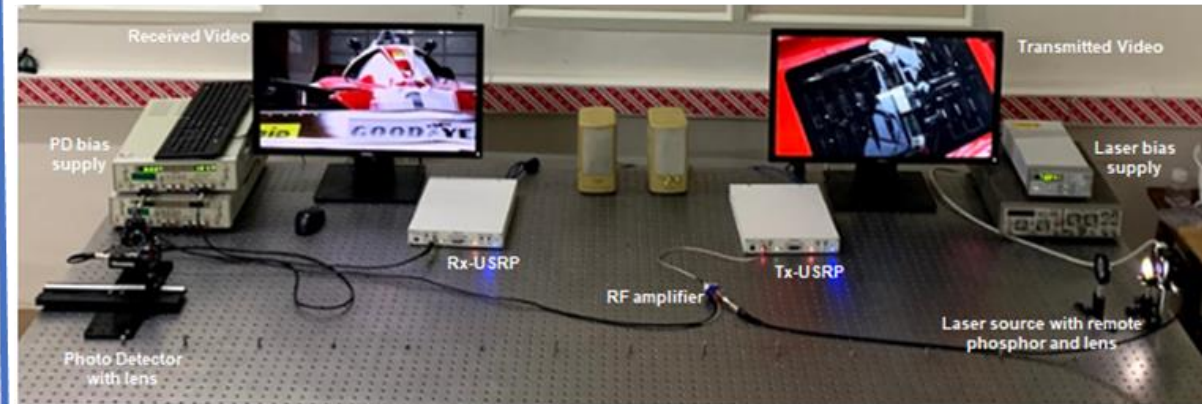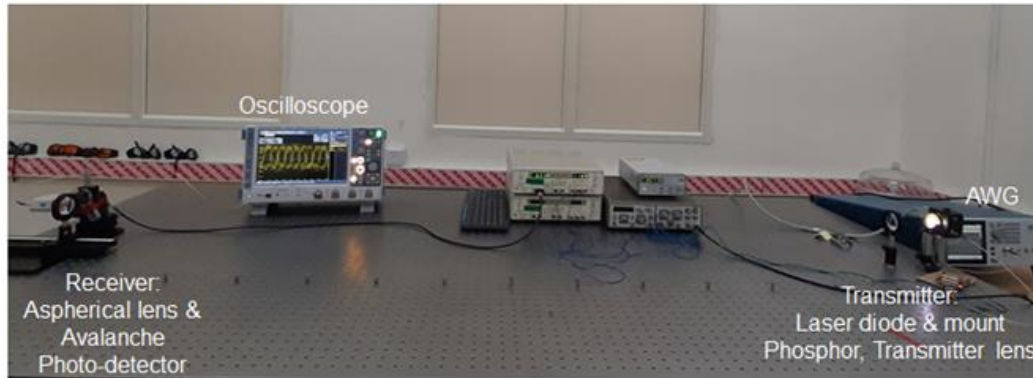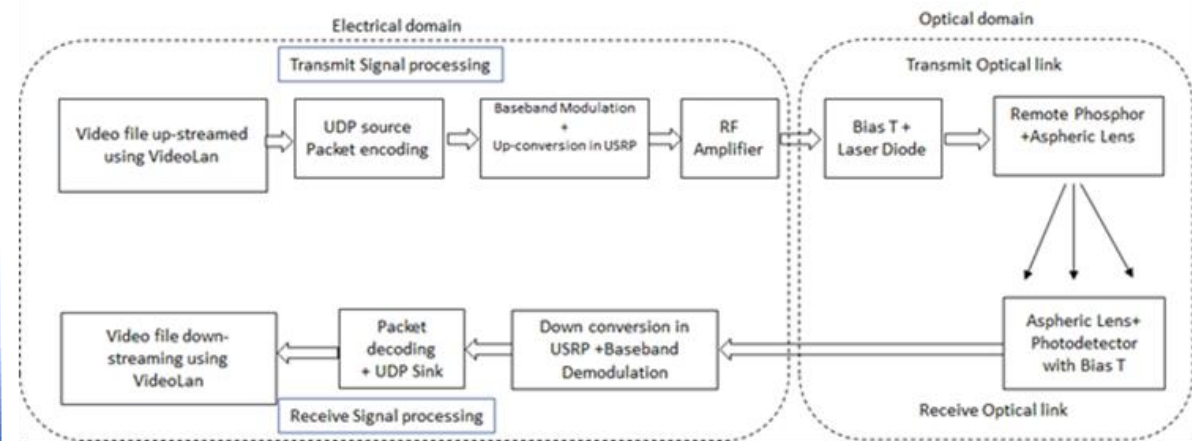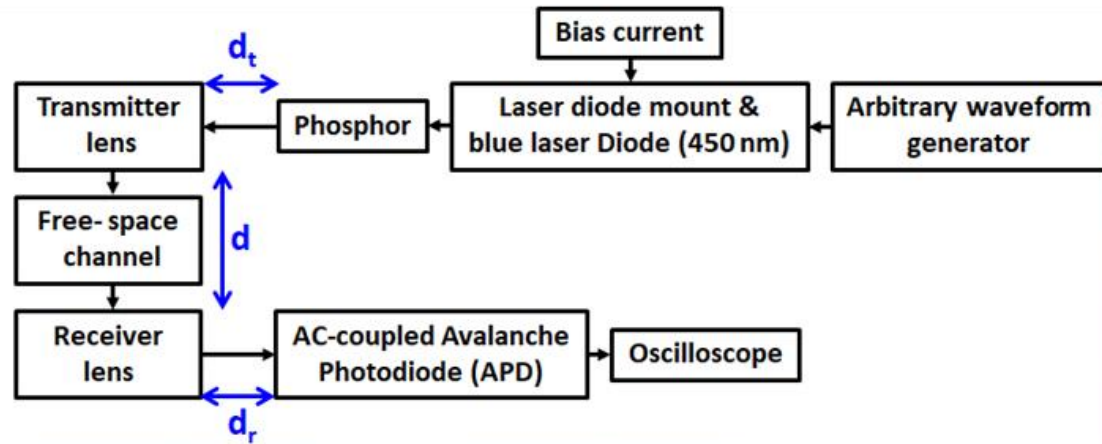
How can the Test Bed be used

Application Users (ex. Public safety/Smart City etc)

■ User Component

App

UE

Test Bed

External Apps

Server

Edge Server
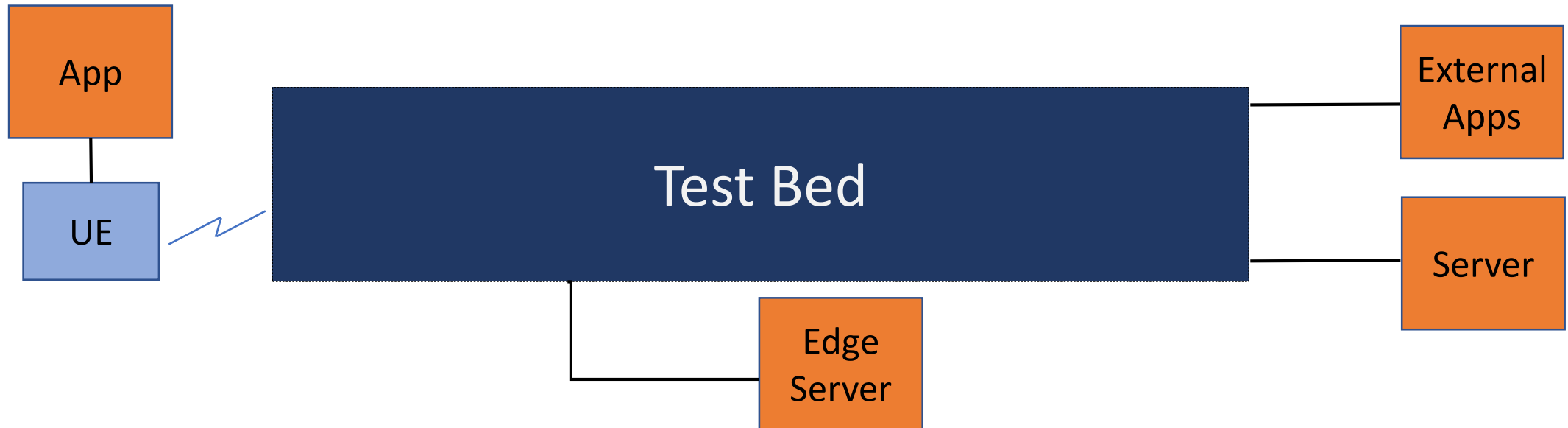
Examples of Usage
- IOT Application developer like Smart city applications, Power System monitoring for Utility etc
- Application developers who use network data Ex. Network Analytics

Start-ups/SMEs (Technology developer)
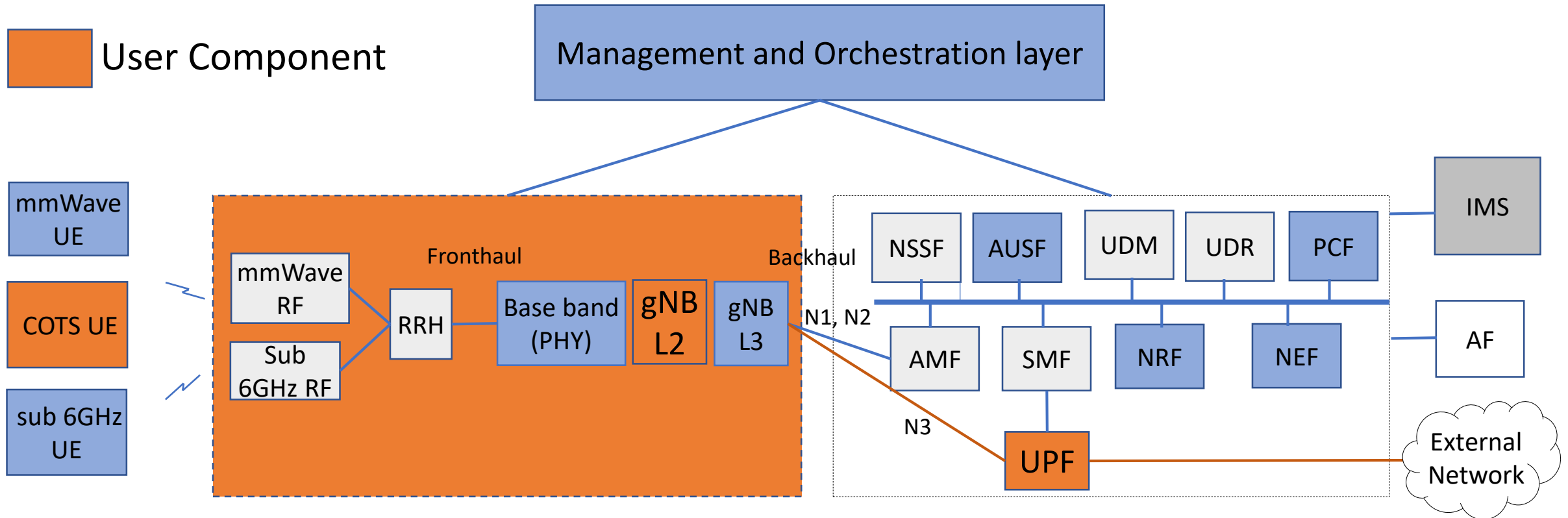
Examples of Usage
- L2 stack brought and validated in the test bed
- UPF Network Function brought and checked in the test bed
- gNodeB or 5G Core interoperated in the test bed

Research user

CEWiT INDIA

Management and Orchestration layer

Channel Estimation

Beam forming

Authentication Algo

IMS

mmWave UE

mmWave RF

Sub 6GHz RF

RRH

Base band (PHY)

gNB L2

gNB L3

NSSF

AUSF

UDM

UDR

PCF

AF

IITH UE

N1, N2

AMF

SMF

NRF

NEF

COTS UE

N3

RRM

UPF

External Network

sub 6GHz UE

- Handover algo
- Admission Control
- etc

- Routing, Switching, Load balancing
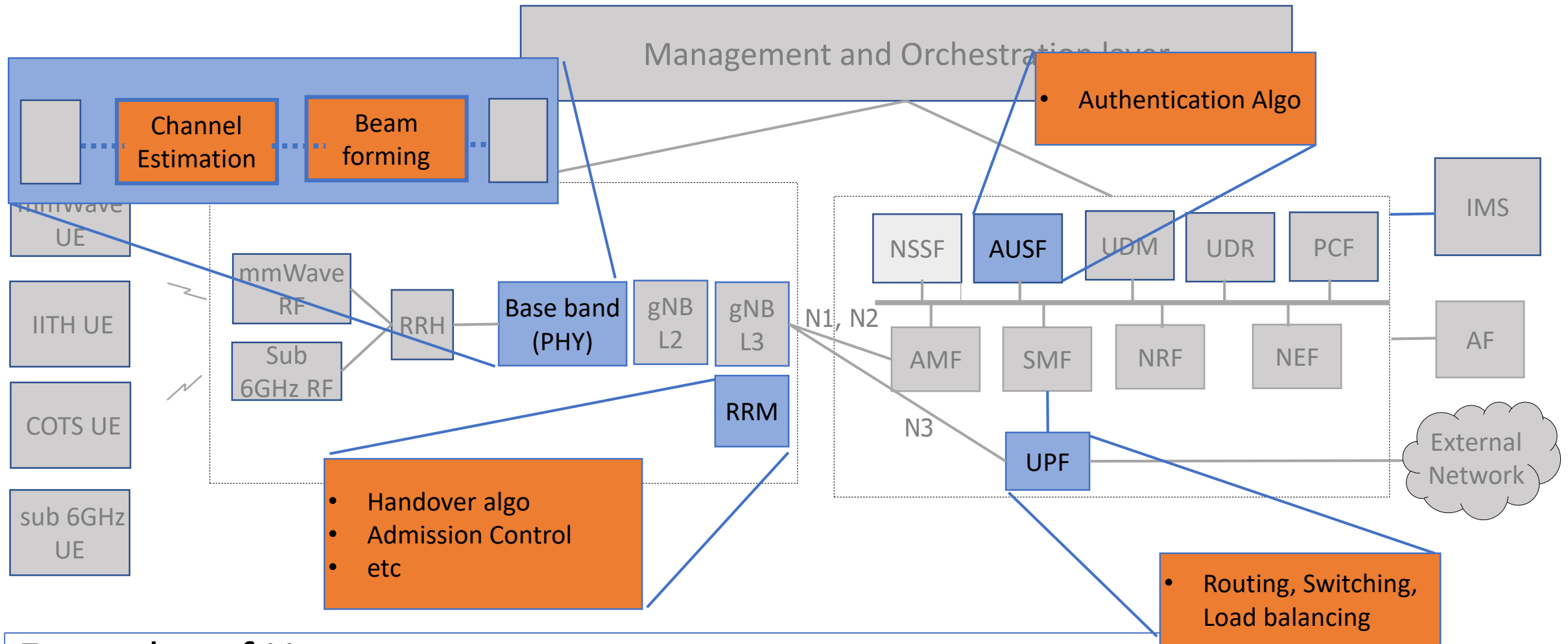
Examples of Usage
- Key algorithm or modules across the subsystems plugged in and analysed in the test bed

Scholars/Students

Management and Orchestration layer

mmWave UE

IITH UE

sub 6GHz UE

Sub 6GHz RF

RRH

Base band

L2

gNB L3

Backhaul

N1, N2

N3

Control Plane Functions

User Plane Function

External Network
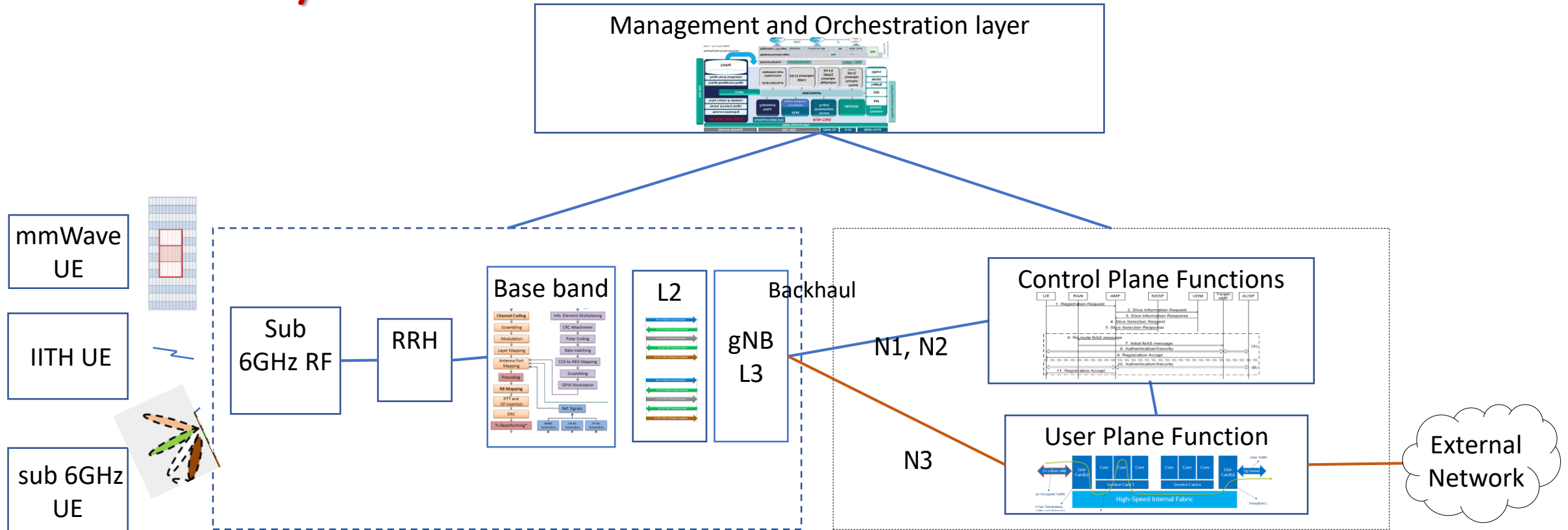
Examples of Usage
- Unlimited!!

Test Bed Users

Test Bed Usage Categories

Use of IPs

Prototypes, Patents, Hardware platforms, ASICs, Stacks, Algo's, Tools

Services and Application Development

AF APIs, TB Management, End to end test bed

5G Test Bed

Hardware platforms, Lab tools, Algo's, APIs

R&D and Product Development

Skill Building

Access levels in the Test Bed

Application access and end-to-end use of the Test bed

Standard interfaces for network nodes

Published interfaces for components

Software and Hardware Modules

Licensed Source code

Open Source

Test Bed Users

Equipment companies
- R&D for product and stack developments

Appln/Solution Developers
- End to end test bed to demo appln
- Pre-interoperability tests
- Understand integration issues with 5G Network

Telecom Startups
- Experience end to end perspectives
- Potential Starting point for product/solution development
- Setup for validations and pre-interoperability

5G Test Bed

Prototypes, Patents, Hardware platforms, Algo's, Tools

HW, ASICs, Module designs, IPs, Stacks, Patents, Lab tools

HW, APIs

Research platforms, Lab tools, Algo's, APIs

Operators
- Understanding of 5G
- In-depth understanding of technical aspects
- Demos based on 5G (Ex.LMLC)

Academic Institutes
- Research and validation of algos
- Implementation perspectives
- Experiential learning tool for 5G

Test Bed Usage for User Categories

❑ Start Up Companies

◊ Use the test equipment for testing purposes

◊ Can integrate their IPs into the test bed

◊ Test their Devices and IoT based solutions

◊ Integrate and validate SDN/NFV based modules for 5G

◊ Utilize Core Network's 5G design and network architecture

❑ Semiconductor companies

◊ ASIC development and integration

◊ Tape Outs and Fabrication

◊ Product IPs

◊ Testing of proprietary algorithms

◊ IoT devices

❑ Technology and Services companies

◊ Integrate and test their Product IPs, Do interoperability testing

◊ Integrate and Test Protocol stack implementation and verification

◊ Test Software for IoT applications

Test Bed Usage for User Categories

- ❑ **Equipment vendors**
  - ◊ Testing and performance evaluation. Examples:
    - o Schedulers enhancements and testing
    - o Control channel design and testing
    - o Radio resource management
    - o Enhancement to proprietary algorithms and testing
      - – Receiver, Link adaptation, HARQ, MIMO etc.
    - o Interference mitigation techniques and performance evaluation
  - ◊ Core network testing
  - ◊ Develop SDN/NFV based products and solutions for 5G

- ❑ **Devices companies**
  - ◊ Testing and performance evaluation. Examples:
    - o Enhancement to proprietary algorithms and testing
      - – Receiver, HARQ, MIMO etc.
    - o CSI/CQI
- ❑ **Application developers**
  - ◊ Integrate and access the network through exposure provided
  - ◊ Run end to end applications

Test Bed Usage for User Categories

❑ Operators

- ◊ Understand 5G perspectives and the technology
  - o Cloud RAN and Massive MIMO, mmWave, 5G Core etc
- ◊ Scheduling algorithm implementation and testing
- ◊ Coverage and capacity studies
- ◊ Traffic adaptation and spectrum resource management
- ◊ Interference mitigation techniques

❑ Academic Institutes

- ◊ Develop and validate algorithms
- ◊ Use for research, academic projects, teaching
- ◊ Understand standardization aspects, participate on 5G related standardization activities and align the research

Connectivity to Test Bed

Examples of Users accessing Test Beds from various Locations

- Local or remote User access to Test Beds through
  - LAN/Intranet
  - NKN
  - Internet/VPN
- Test Beds interconnected through
  - NKN
  - Internet

User of TB B, from Institute A

User of TB A, From Institute A

5G TB- A in Institute A

NKN

5G TB - B in Institute B

LAN

Internet

User -TB B, Company/ Institute E

User of TB C, From Company/Institute D

VPN

5G TB -C in Institute C

LAN

User of TB C or A From Institute C

Timelines

INTEGRATED TEST BED SUMMARY 1/2

Version	Summary Features Available
Version 0 **May 1, 2019**	• Individual RF, RRH, BB subsystems ready for demo to users. • Platform/Tool providers get technical feedback.
Version 1 **Q1, 2020**	• Integrated end to end basic functionality ready for demo for users. • Users can understand the 5G aspects. • Experiential learning tool for 5G technology. • Participating Institutes get an initial version of working hardware for internal purposes

INTEGRATED TEST BED SUMMARY 2/2

Version	Summary Features Available
Version 2 **September 1, 2020**	• Integrated end to end functionality ready for demo for users. • Users can run end to end applications. • Users can plug in their own modules in RAN or Core and run them in the end to end functionality within the functionality of Ver2. • Researcher can put in their algorithms and check performance. • Users can bring in AFs which can fetch data from the Network for their application domain requirements. • Software and Hardware ready for initial licensing.
Version 3 **April 1, 2021**	• Integrated end to end functionality ready for use case demos like LMLC, Dense Urban, IOT scenarios. • Users can run end to end applications including IOT. • Users can plug in their own modules in RAN or Core and run them in the end to end functionality. • Users can bring in AFs which can fetch data from the Network for their application domain requirements. • Users can use slicing techniques to understand its effectiveness. • Users can bring in a network element and integrate with the test bed. • Users can license parts of the test bed Software and Hardware.

INTEGRATED TEST BED – What USER Gets

Version	How the Test Bed Can be Used
Version 1 Q1, 2020	Initial release of Access User Interface available for the Test bed General Users can come and use the Test equipment in the lab in a controlled Manner
Version 2 September 1, 2020	Full fledged user interface to access the test bed from remote is available. APIs for all major features available. General Users can come and test their algorithms and equipment through the APIs General Users can reserve, schedule, access and use from remote locations General Users can come and use the Test equipment in the lab in a controlled Manner
Version 3 April 1, 2021	Users can reserve, schedule, access and use from remote locations. TEST BED FULLY FUNCTIONAL.

Thank You