IIT HYDERABAD

Ubiquitous Connectivity for Bridging the Digital Divide and Integration with NTN

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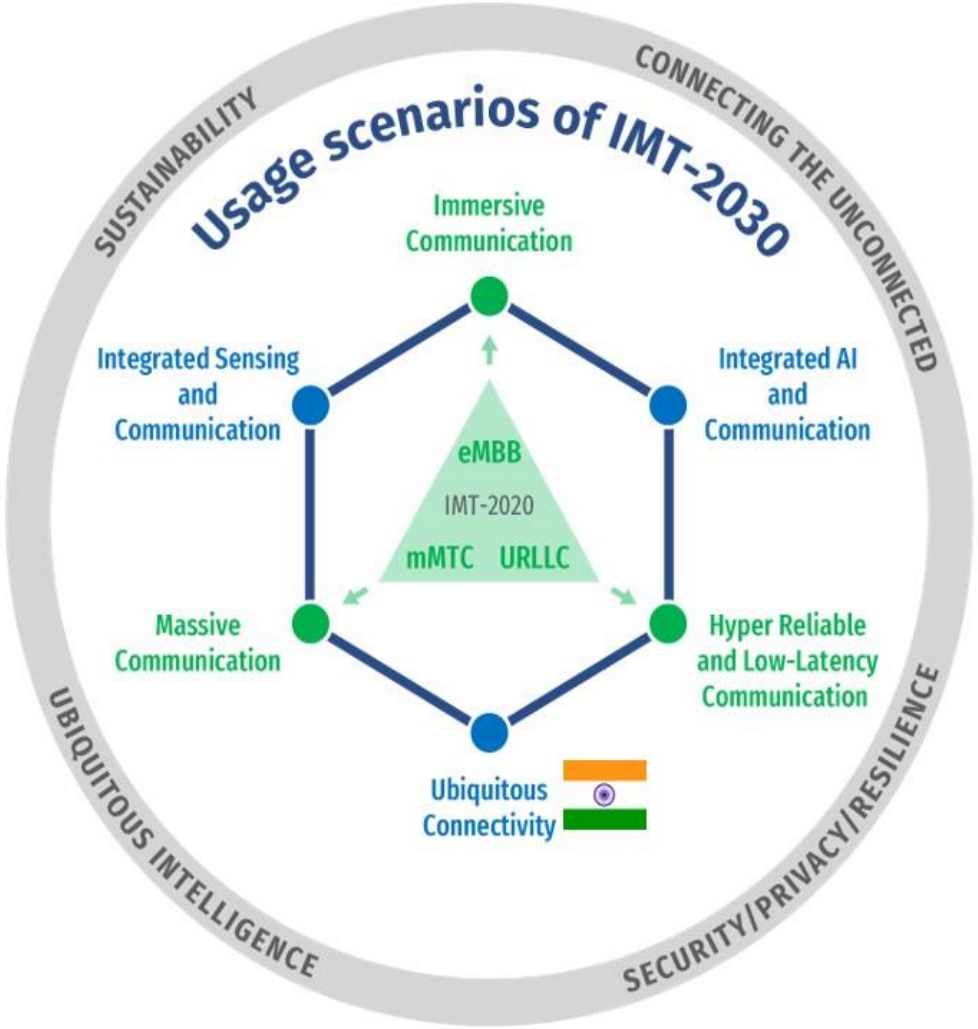
Framework & objectives of the future development of IMT for 2030+

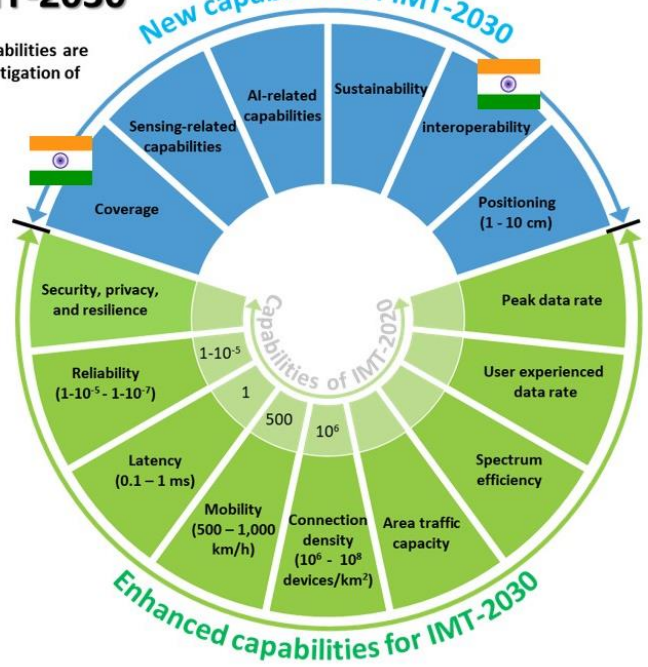


Focus on better serving the networked society in developed and developing countries

Evolution of existing IMT, and interworking with other networks such as Satellite are addressed

Capabilities of IMT-2030

NOTE: The range of values given for capabilities are estimated targets for research and investigation of IMT-2030.



IMT 2030 - Goals

The Recommendation highlighted several goals that IMT-2030 aims to achieve, including:

Goals	Aims to Achieve
Inclusivity	Bridging the digital divide and ensuring meaningful connectivity for everyone
Ubiquitous connectivity	Providing affordable connectivity and basic broadband services with extended coverage, including sparsely populated areas
Interworking	Supporting service continuity and flexibility through close interworking with non-terrestrial network implementations, existing IMT systems, and other access systems

Worldwide 3.4 Billion people live in rural areas of which 900 Million people live in Rural India

Worldwide ~2.9 Billion people do not have access to connectivity

How to Achieve Ubiquitous Connectivity?

What is Ubiquitous Connectivity?

Providing affordable connectivity and basic broadband services with extended coverage, including sparsely populated areas

Achieving high-speed broadband coverage in a sparsely populated area that is located within 10-50Km link from the fiber drop point can be the research design target

This is a critical use case that is not solved today!

How to achieve Ubiquitous Connectivity?

Terrestrial Component with Large Coverage

NTN as a complementary service. NTN offers coverage anywhere, at any time. However, NTN has limited capacity (No of simultaneous users that be served)

Research Targets:

10-50Km links

What are the key technologies that will achieve Ubiquitous Connectivity?

How to combine NTN with Terrestrial?

How to achieve Ubiquitous Connectivity?

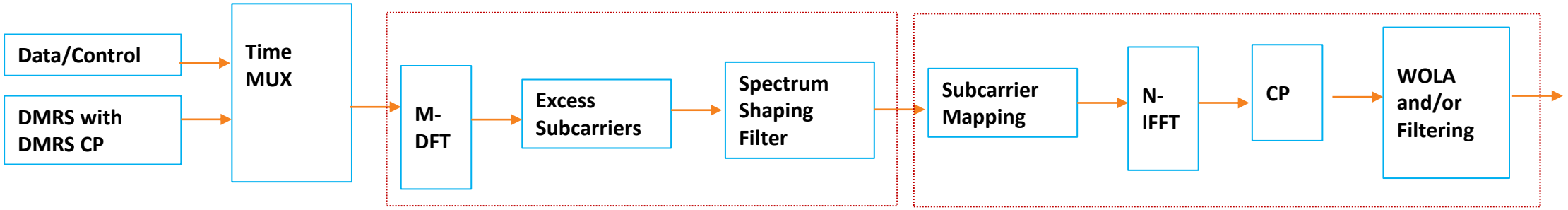
There are four key ingredients

- New Waveform – Power Efficiency
- S-MIMO: Extremely Large Antenna Arrays
- Next Gen IAB: Chain of Relays

Tight Integration between Terrestrial and NTN

These are the opinions of the author based on preliminary academic research done at IIT Hyderabad and WiSig Networks. Research prototyping and field experiments to be done to validate these claims

6G Waveform: Orthogonal Time Frequency Division Multiplexing (OTFDM)



Time Division Multiplexing in one Symbol

- Time multiplexing of Data and Control and DMRS with DMRS CP
- Instantaneous Channel Estimation with low DMRS overhead
- Information transfer in one shot with the Least Possible Latency

DFT Excess BW Spectrum Shaping Filter

- Nyquist Criterion for Zero ISI
- Excess BW signal shaping Controls the ISI caused by the pulse, reduces the tails of the ISI channel power to a below-noise floor, Reduces Effective ISI channel length, Enables DMRS-based estimation of the effective ISI channel
- Low PAPR, High PA efficiency

Standard OFDM Operations

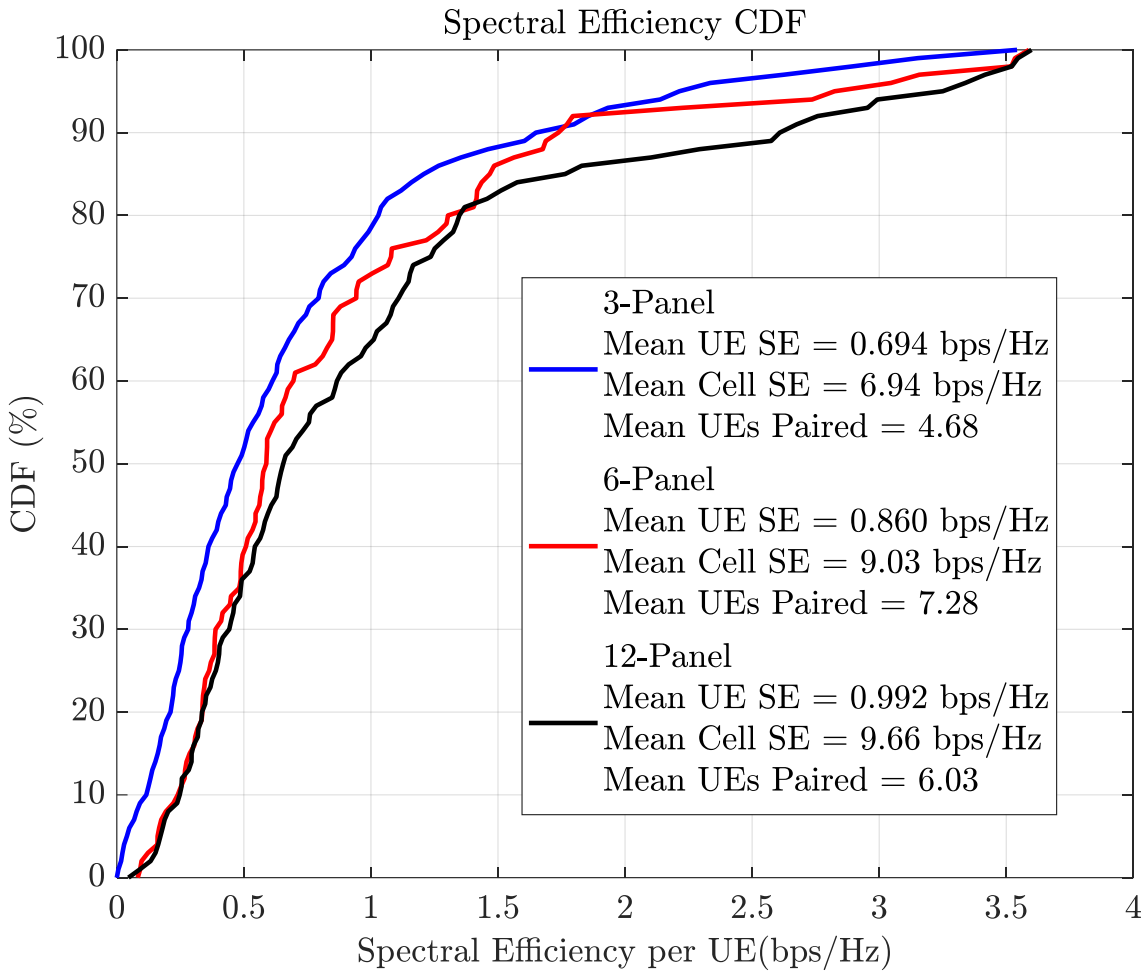
- Subcarrier mapping enables the multiplexing of multiple users/signals
- CP to offer frequency domain receiver processing
- Same spectral properties as OFDM - WOLA/filter for spectral confinement

OTFDM achieves the targets: low PAPR, High Power Efficiency, Hyper low-latency

Structural MIMO: Coverage Expansion and Spectrum Creation

S-MIMO: Structural arrangement of antenna panels using large antenna arrays
Spectrum Creation: The possibility of reaching 100 Bits/Sec/Hz has been showcased
Coverage Expansion: Highly directional beams

S-MIMO: Network Simulation



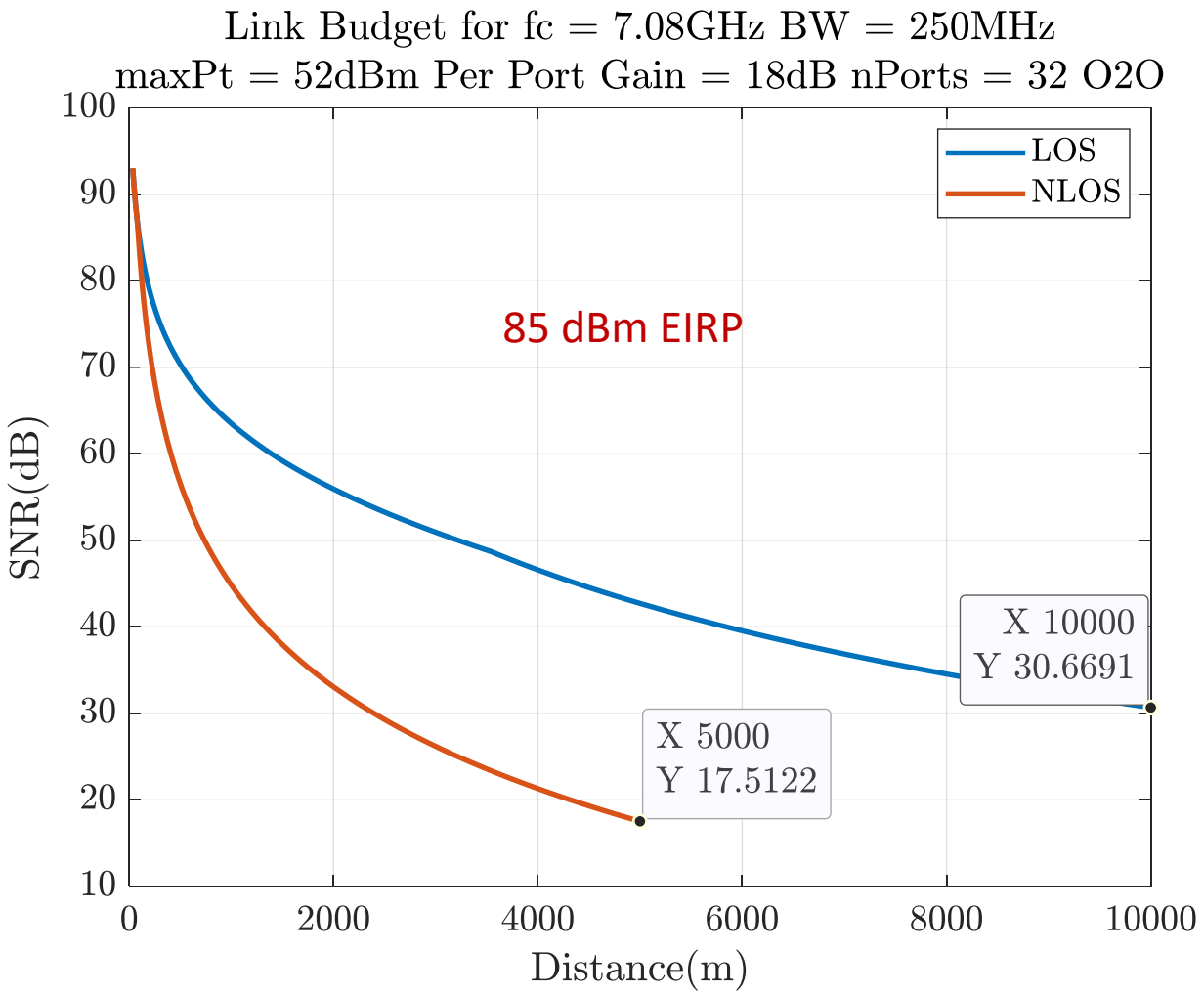
SE numbers in bps/Hz

Antenna Panels	No of Tx Ports /Panel	No of Antenna elements all Panels combined	5% SE	Mean UE SE	Average SE/Panel (Bits/sec/Hz)	Total SE in 360-deg (Bits/sec/Hz)
3	32	192	0.04	0.694	6.94	21
6		1152	0.16	0.860	9.03	54
12		4608	0.17	0.992	9.66	116

DL S-MIMO MU MIMO SE with multiple antenna panels – Mid-band

- 116 Bits/Sec/Hz feasible in 6G as opposed to 24 bits / sec / Hz in 5G
- 4.8 fold SE improvement feasible

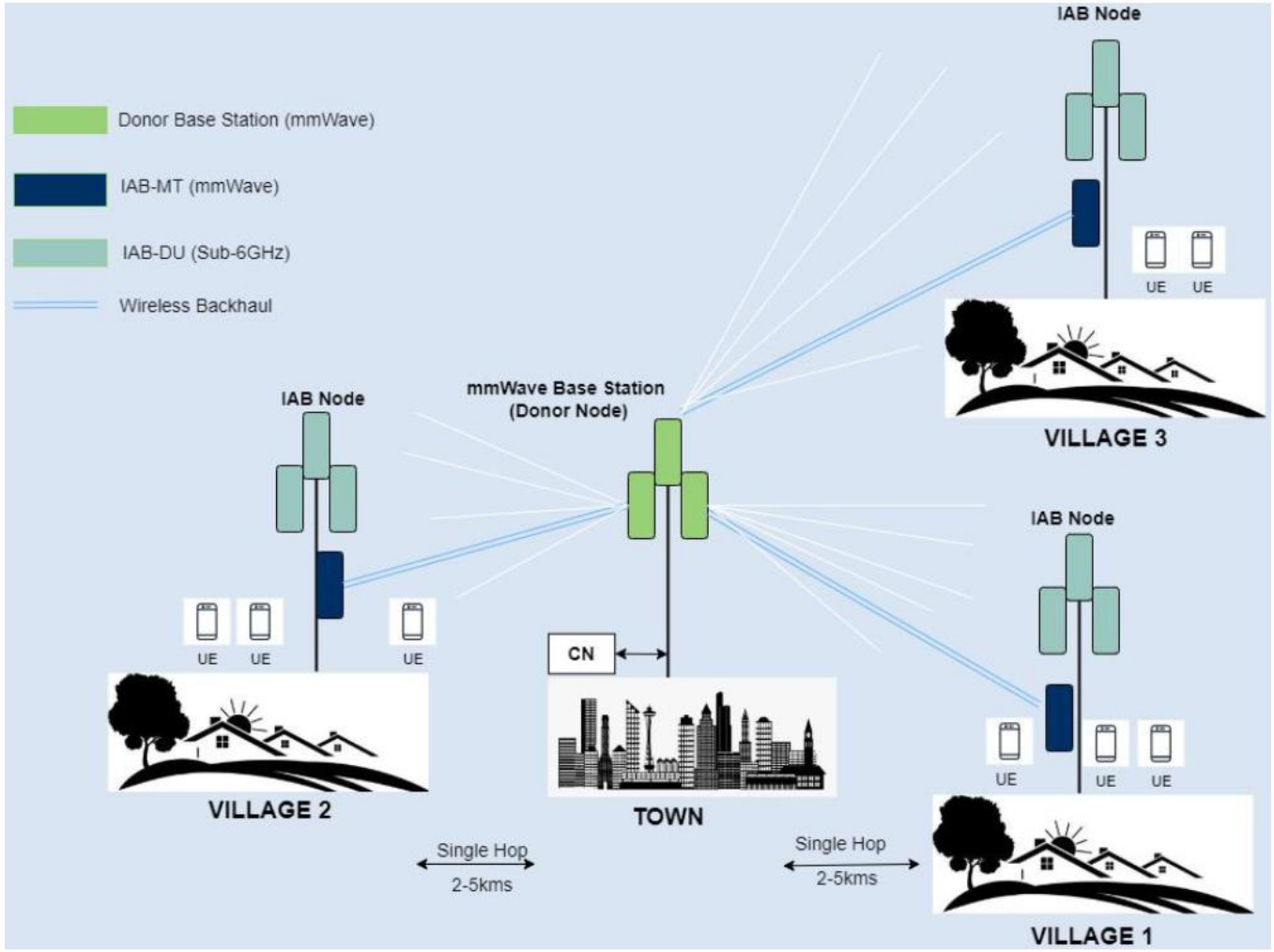
Coverage of 6G in New Frequency Bands: Link Budget for 7GHz, RMa



5-10Km single link coverage feasible in 6G

Large Antenna Arrays used to Expand Coverage

Next Gen Integrated Access Backhaul (IAB)



5G IAB Architecture

- 6G IAB Research Targets
  - Up to 50 Km link from Fiber drop - using a chain of relays
  - FR1/FR2/FR3 used for access and back-haul in different combinations

Tightly Integrated NTN and Terrestrial Systems

Reuse 5G NTN Specifications for 6G NTN

Applications

- Base Stations with NTN Back-haul
- UE/CPE switches between Terrestrial and Satcom for example:
- Terrestrial and GEO Satcom NB IoT offered by a single modem
- 6G CPEs switch between terrestrial and NTN for e.g., home broadband access

Key Takeaways

What is Ubiquitous Connectivity?

Providing affordable connectivity and basic broadband services with extended coverage, including sparsely populated areas

Achieving high-speed broadband coverage in a sparsely populated area that is located within 10-50Km link from the fiber drop point can be the research design target

Research Targets:

10-50Km link from fiber drop

Key technologies that will achieve Ubiquitous Connectivity:

New Waveform

S-MIMO: Large Arrays

Chain of relays using FR1/2/3 frequency bands

Dual mode NTN and Terrestrial CPE/UE

NTN Back-haul

6G WHITE PAPER: MEETING IMT2030 PERFORMANCE TARGETS: THE POTENTIAL OF OTFDM WAVEFORM AND STRUCTURAL MIMO TECHNOLOGIES

https://bharat6galliance.com/img/pdf/Whitepaper_on_The_Potential.pdf

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Thank You !!

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