3GPP Self-evaluation Methodology and Results

"Self-evaluation Results"

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3GPP TSG-RAN1 Vice-Chairman

3GPP Self-evaluation for LTE-Advanced Summary

- The 3GPP self-evaluation has shown that the LTE Release 10 & beyond (LTE-Advanced) SRIT and the individual FDD RIT and TDD RIT components completely satisfy the criteria of Step 7 and should move forward to Step 8 of the process.
- In particular, the SRIT and the individual FDD RIT and TDD RIT components meet all the requirements in all four of the four defined test environments.
- The evaluation results were based on the rigorous calibration effort.

RIT: Radio Interface Technology
SRIT: Sets of RIT

Outline

1. Main assumptions (Recap)
   - 1.1 Evaluated DL schemes
   - 1.2 Evaluated UL schemes
   - 1.3 DL control overhead assumptions
2. Results: Peak spectrum efficiency
   - 2.1 DL peak spectrum efficiency
   - 2.2 UL peak spectrum efficiency
3. Results: Full-buffer spectrum efficiency
   - 3.1 Indoor (InH)
   - 3.2 Microcellular (UMi)
   - 3.3 Base coverage urban (UMa)
   - 3.4 High speed (RMa)
4. Results: VoIP
   - 4.1 FDD
   - 4.2 TDD
5. Results: Mobility
   - 5.1 FDD
   - 5.2 TDD
6. Simulator calibration
7. Conclusion

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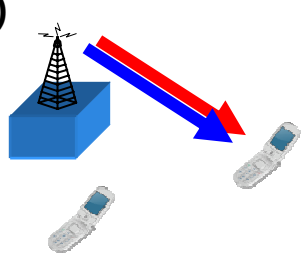
1.1 Evaluated downlink schemes (Full-buffer spectrum efficiency)

- LTE Rel-8

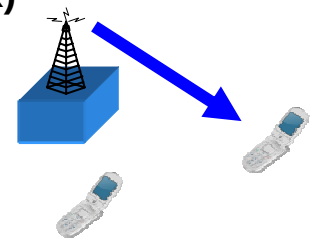
Single-user MIMO (SU-MIMO)

Ex)



Single-layer beamforming (Single-layer BF)

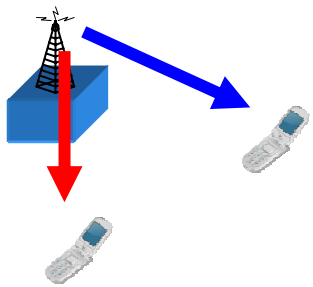
Ex)



- LTE-Advanced

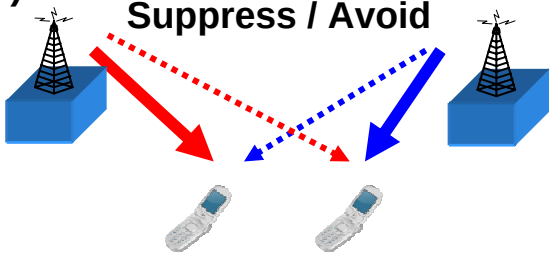
Multi-user MIMO (MU-MIMO)

Ex)



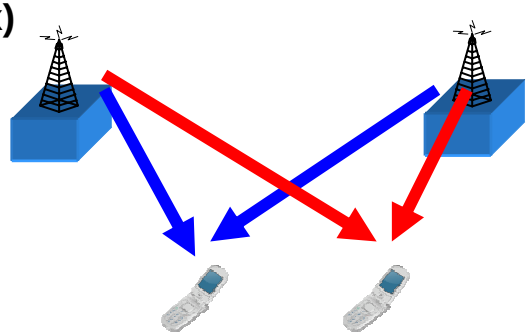
Coordinated scheduling/beamforming CoMP (CS/CB-CoMP)

Ex)



Joint processing CoMP (JP-CoMP)

Ex)



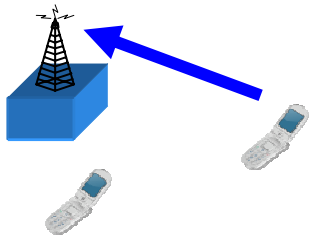
Various schemes have been evaluated

1.2 Evaluated uplink schemes (Full-buffer spectrum efficiency)

- LTE Rel-8

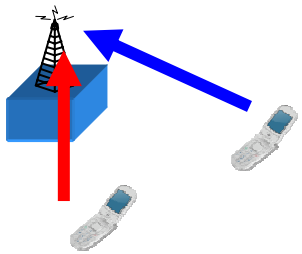
Single-input multiple-output (SIMO)

Ex)



Multi-user MIMO (MU-MIMO)

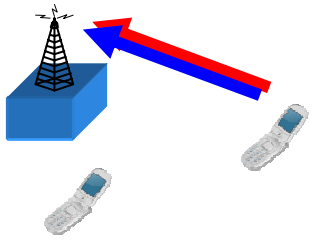
Ex)



- LTE-Advanced

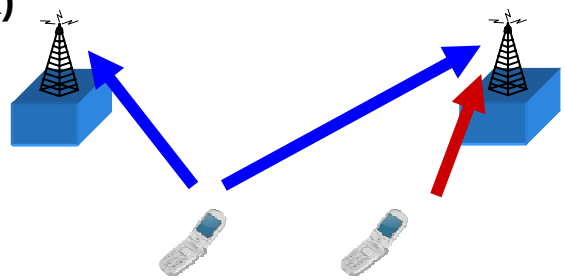
Single-user MIMO (SU-MIMO)
MU-MIMO

Ex)



CoMP

Ex)



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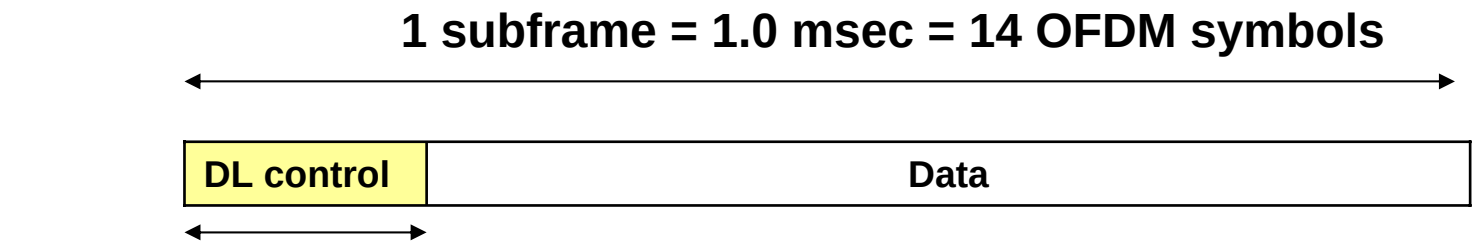
1.3 DL control channel overhead assumption



***L*: OFDM symbols (L=1, 2, 3)**

- Downlink performances have been evaluated taking into account the downlink overhead for L = 1, 2 and 3 cases
- Dynamic assignment of L is supported already in the Rel. 8 specification

  → Average overhead depends on the environments

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2.1 Downlink peak spectrum efficiency

- LTE Rel. 8 fulfills ITU-R requirements
- Further improved performance can be achieved by using additional technology features (8-layer spatial multiplexing)

DL peak spectrum efficiency for FDD

Scheme	Spectral efficiency [b/s/Hz]
ITU-R Requirement	15
Rel. 8 4-layer spatial multiplexing	16.3
8-layer spatial multiplexing	30.6

DL peak spectrum efficiency for TDD

Scheme	Spectral efficiency [b/s/Hz]
ITU-R Requirement	15
Rel. 8 4-layer spatial multiplexing	16.0
8-layer spatial multiplexing	30.0

Assumptions

- 4 layers (LTE Rel-8)
  8 layers (LTE-A)
- 1 symbols for DL control channel
- Common RS (LTE Rel-8)
  Common + Demodulation RS (LTE-A)
- PBCH and Sync. Signal overhead
- For TDD,
  - ✓ 4 DL : 2 SP : 4 UL
  - ✓ 12 DwPTS : 1 GP : 1 UpPTS

2.2 Uplink peak spectrum efficiency

- LTE-A with 2-layer spatial multiplexing fulfills ITU-R requirements
- Further improved performance can be achieved by using additional technology features (4-layer spatial multiplexing)

UL peak spectral efficiency for FDD

Scheme	Spectral efficiency [b/s/Hz]
ITU-R Requirement	6.75
2 layer spatial multiplexing	8.4
4 layer spatial multiplexing	16.8

- Assumptions
- 2 layers
  4 layers
- UL control channel
  (1 PRB / 10MHz / 1 msec)
- Physical random access channel
  (6 PRB / 10MHz / 10 msec)

UL peak spectral efficiency for TDD

Scheme	Spectral efficiency [b/s/Hz]
ITU-R Requirement	6.75
2 layer spatial multiplexing	8.1
4 layer spatial multiplexing	16.1

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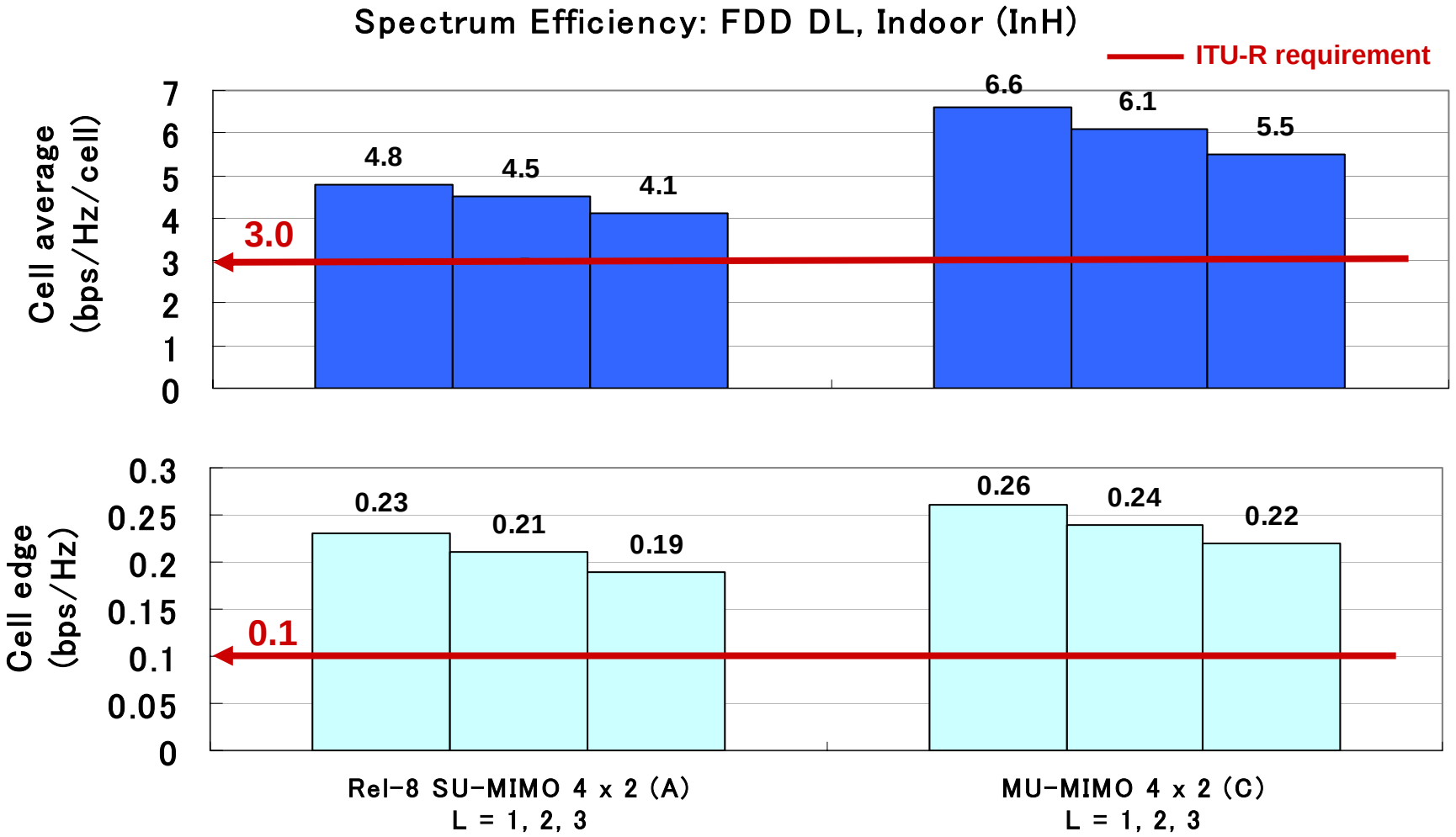
3.1 Indoor (InH) results

3.1 Indoor environment (Downlink, FDD)

- LTE Rel. 8 with SU-MIMO 4x2 (even with maximum DL control overhead (L = 3)) fulfills ITU-R requirements
- Further improved performance can be achieved by using additional technology features (MU-MIMO 4x2)



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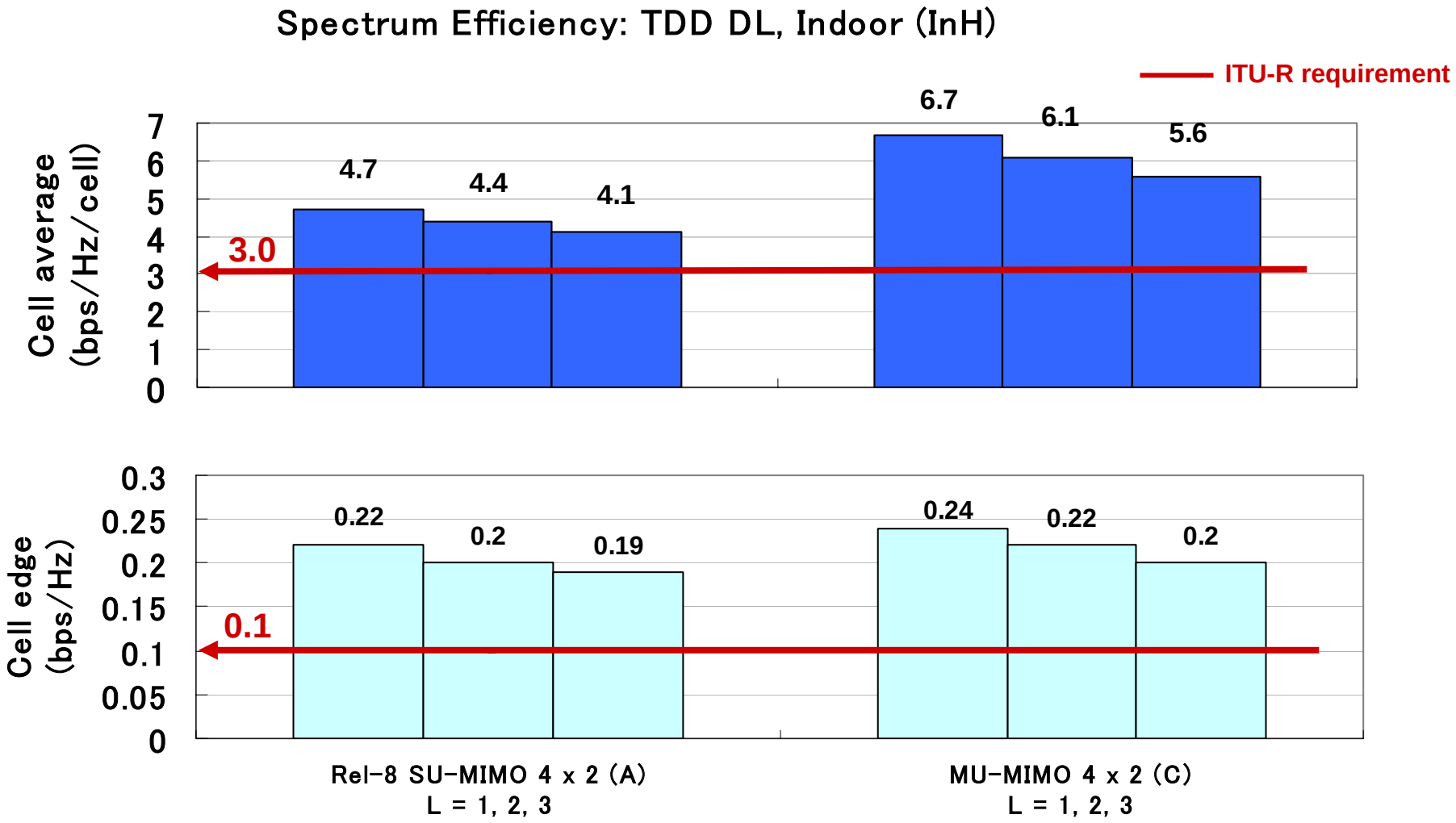
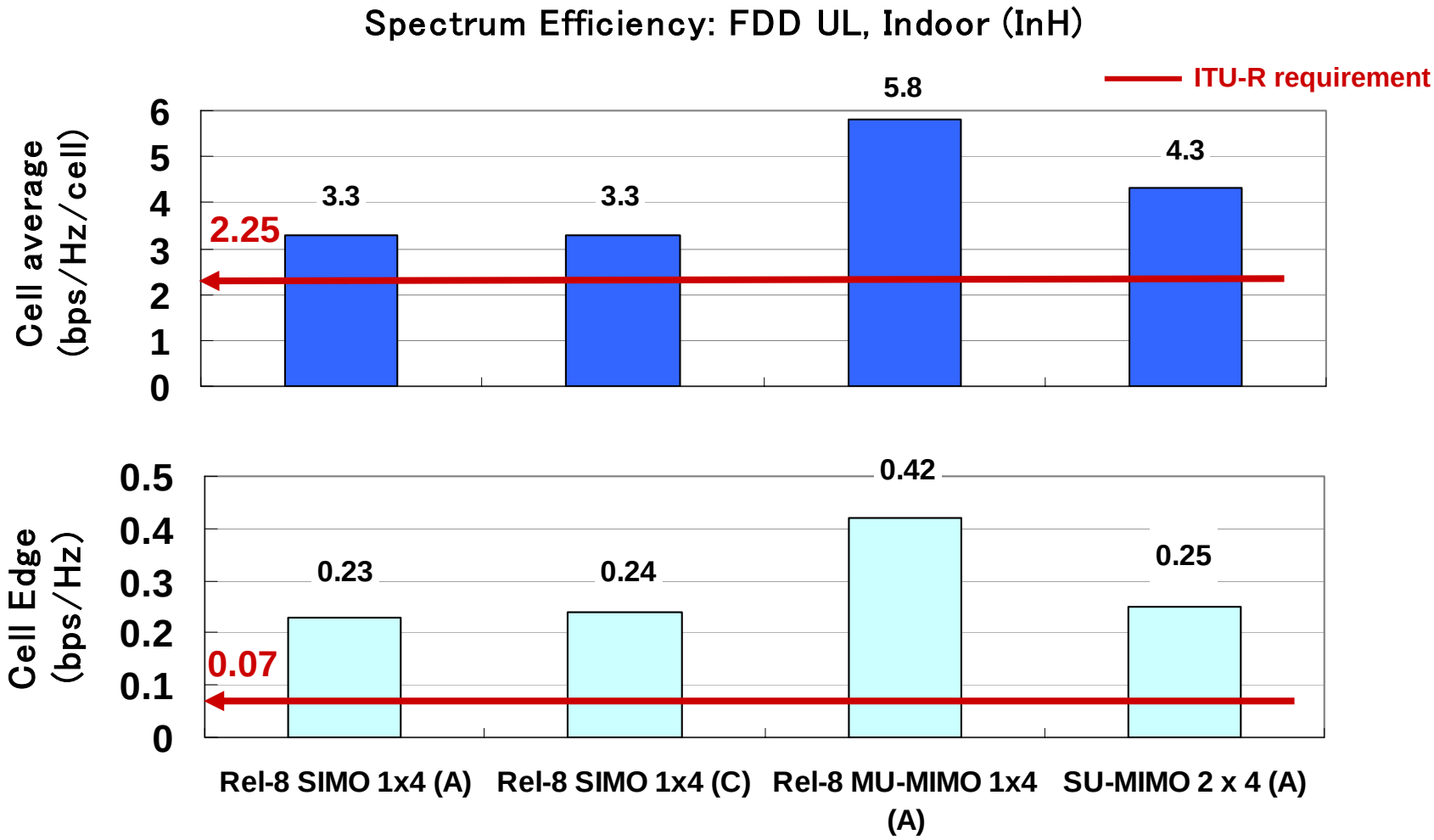


3.1 Indoor environment (Uplink, FDD)

- LTE Rel. 8 with SIMO 1x4 fulfills ITU-R requirements
- Further improved performance can be achieved by using additional technology features (e.g., LTE Rel. 8 MU-MIMO 1x4, SU-MIMO 2x4)



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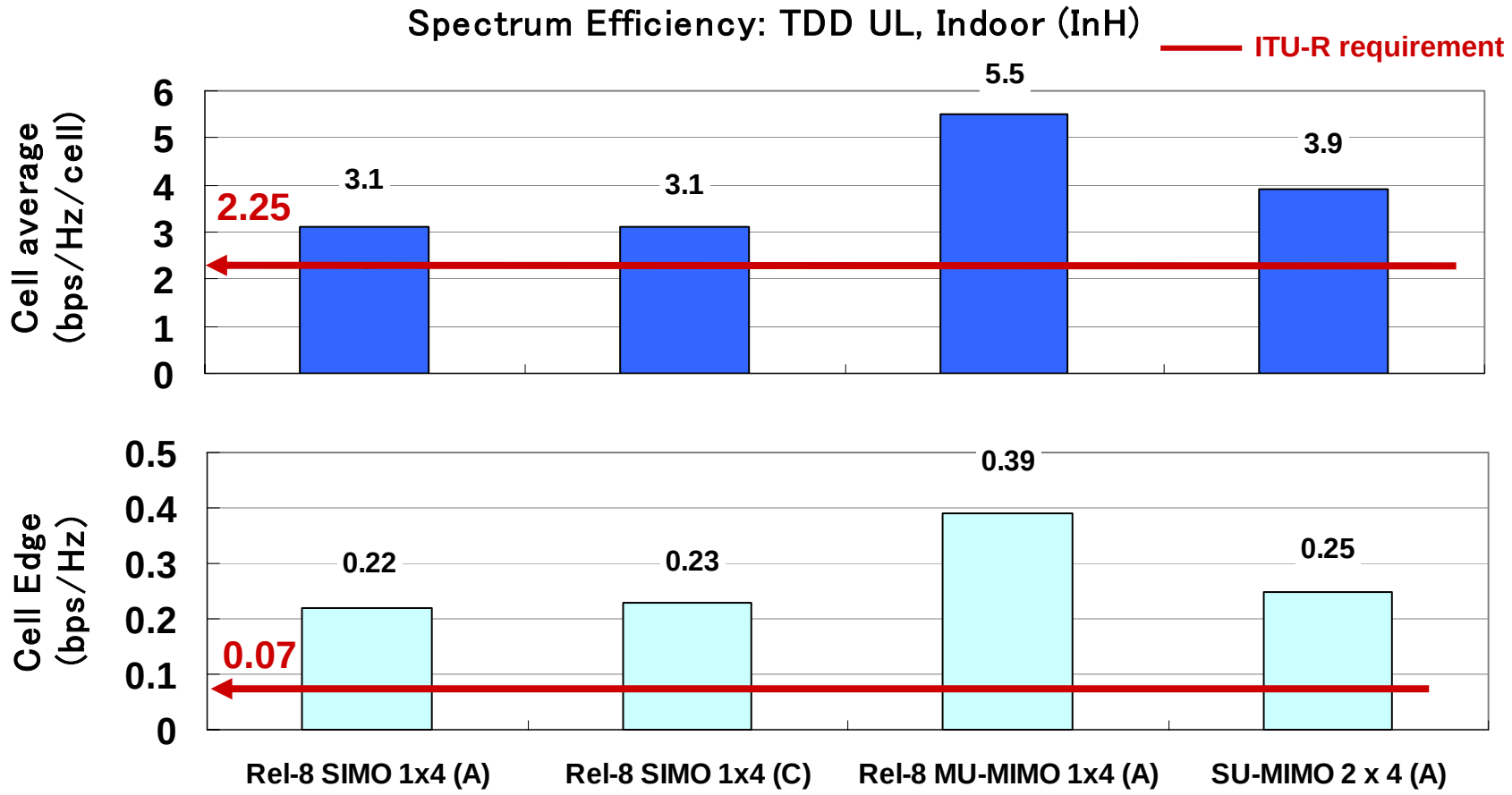
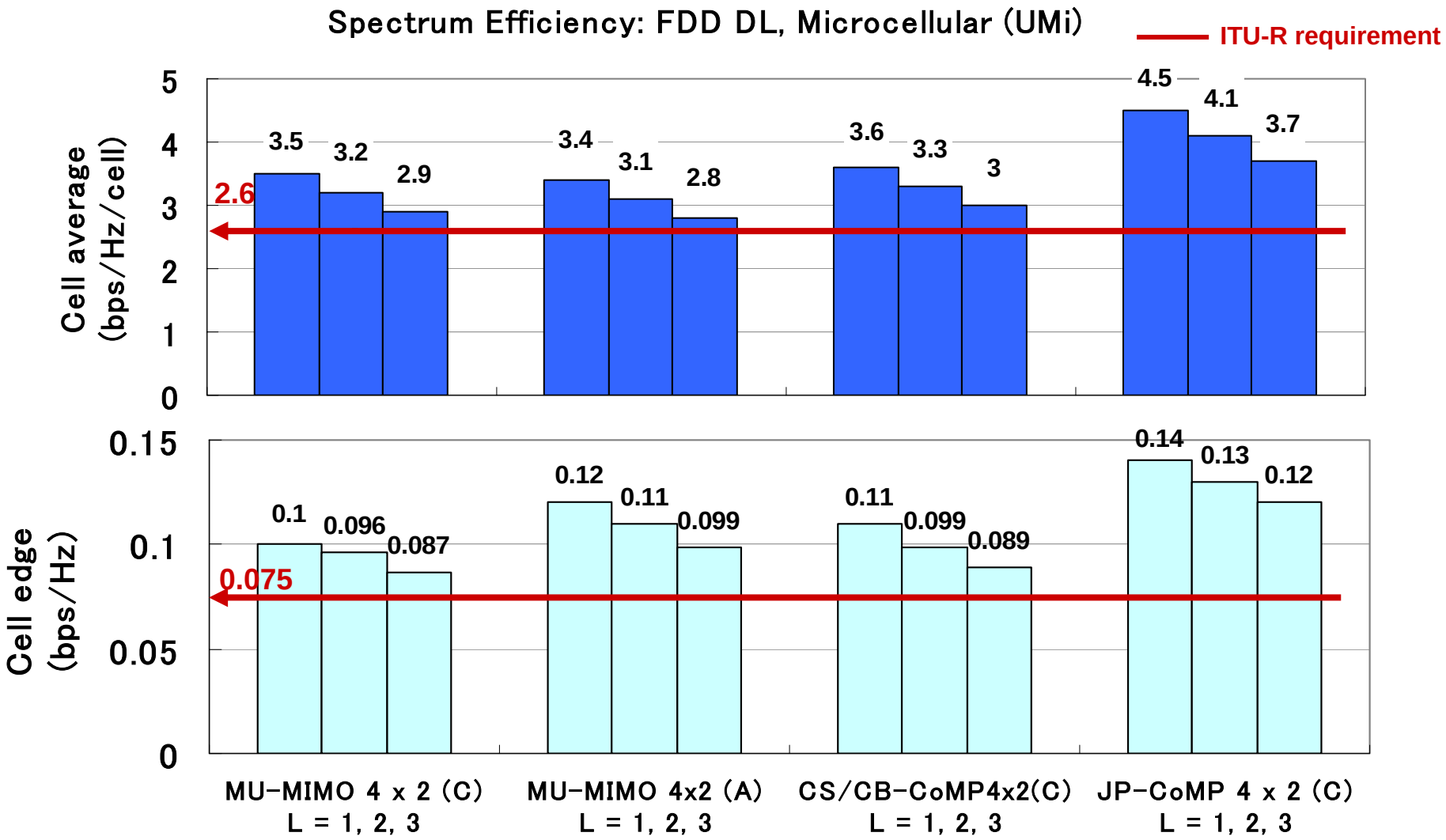


3.2 Microcellular (UMi) results

3.2 Microcellular environment (Downlink, FDD)

- **Extension of LTE Rel. 8 with MU-MIMO 4x2 (even with maximum DL control overhead (L = 3)) fulfills ITU-R requirements**
- **Further improved performance can be achieved by using additional technology features (e.g., CS/CB-CoMP 4x2, JP-CoMP 4x2)**



3.2 Microcellular environment (Downlink, TDD)

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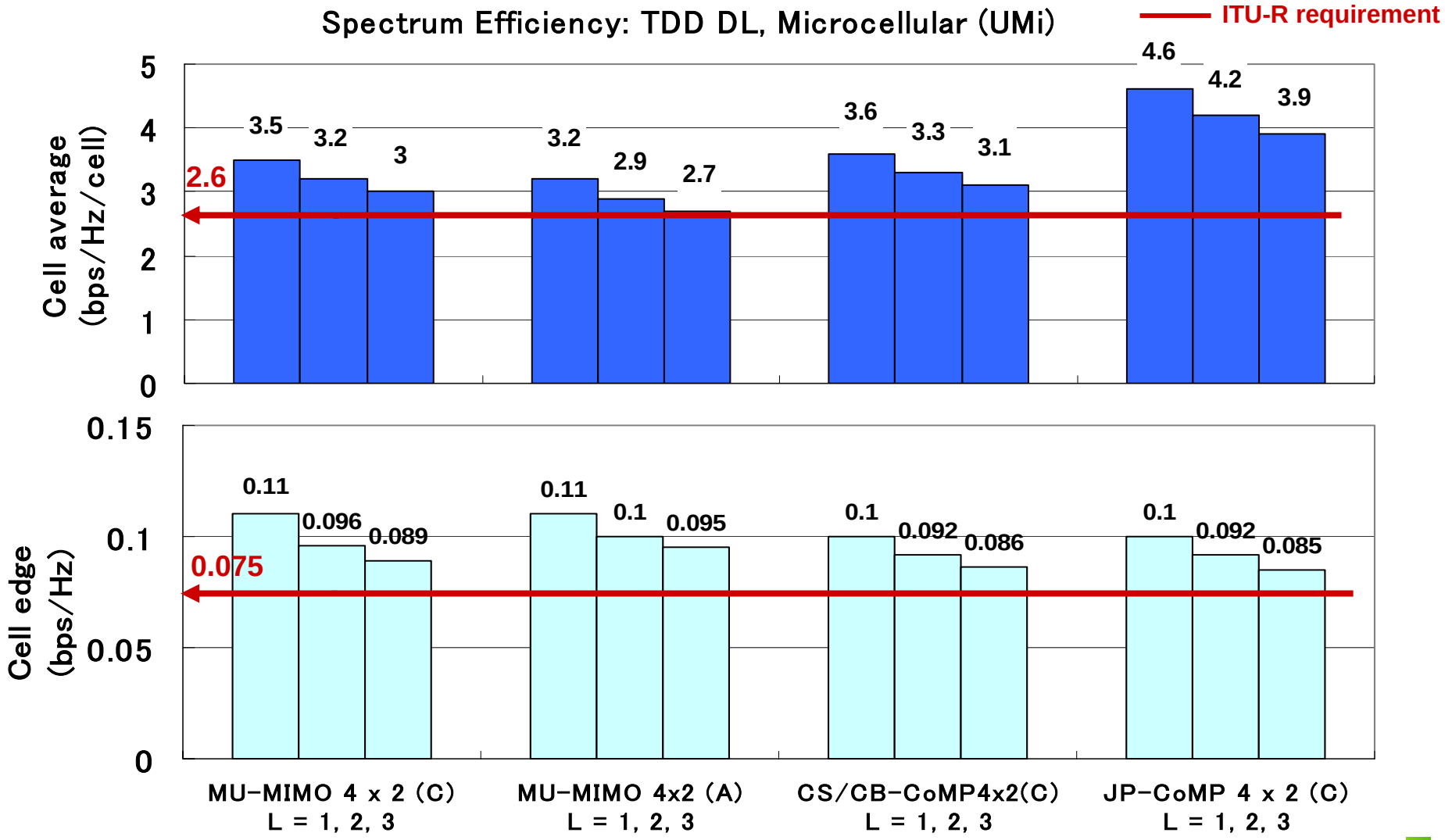
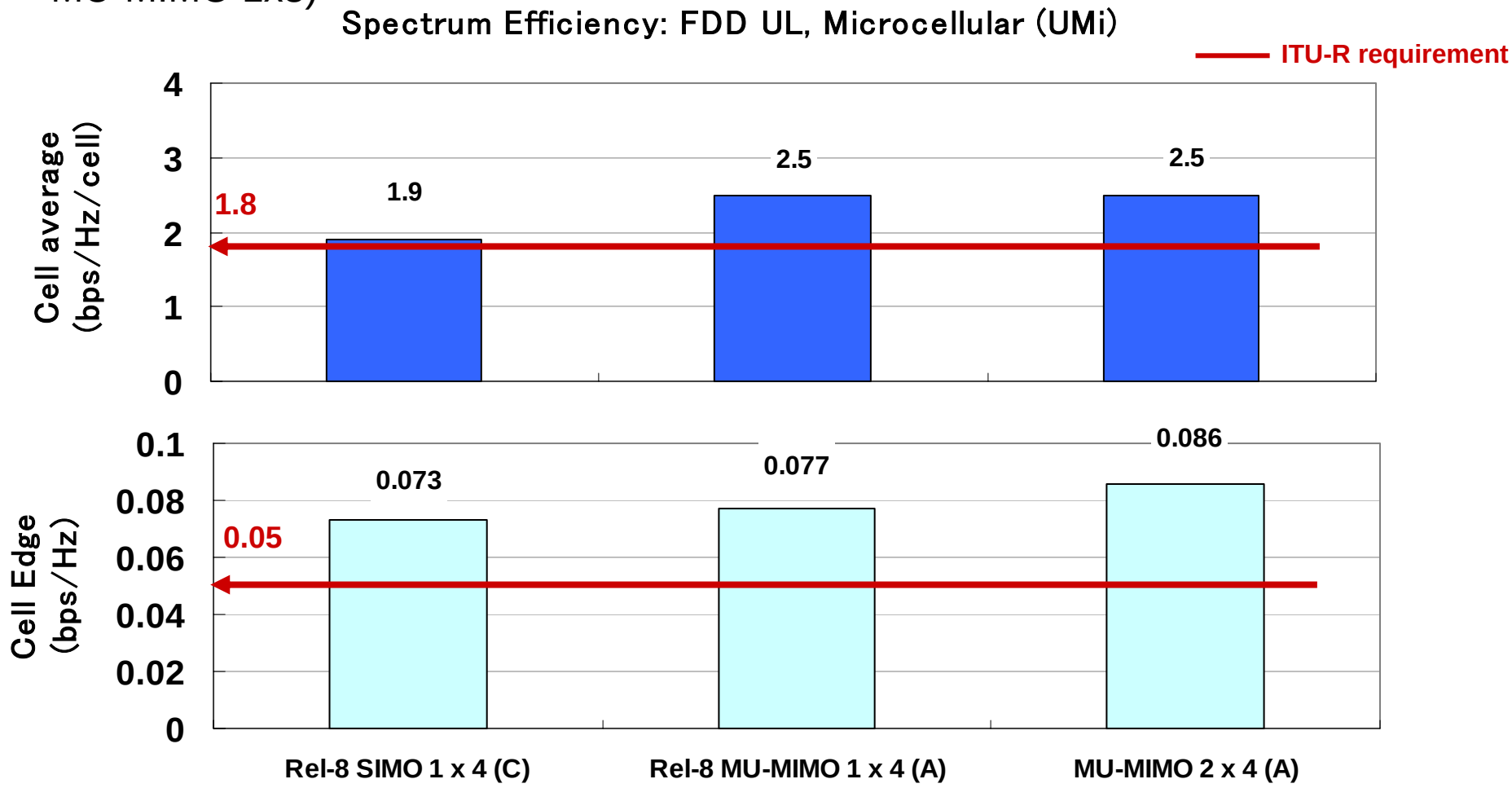


3.2 Microcellular environment (Uplink, FDD)

- LTE Rel. 8 with SIMO 1x4 fulfills ITU-R requirements
- Further improved performance can be achieved by using additional technology features (e.g., LTE Rel. 8 MU-MIMO 1x4, MU-MIMO 2x4, and MU-MIMO 1x8)



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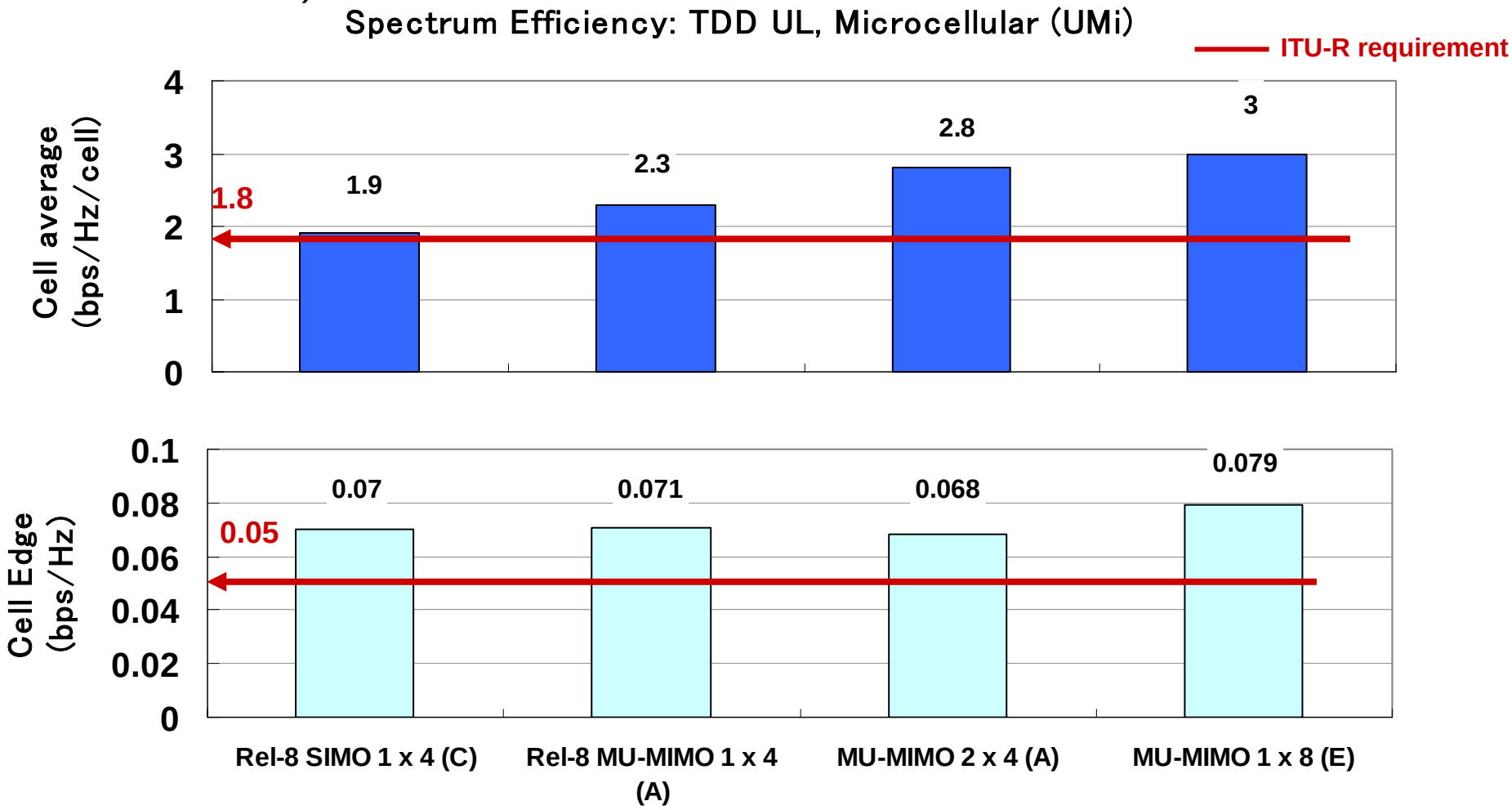
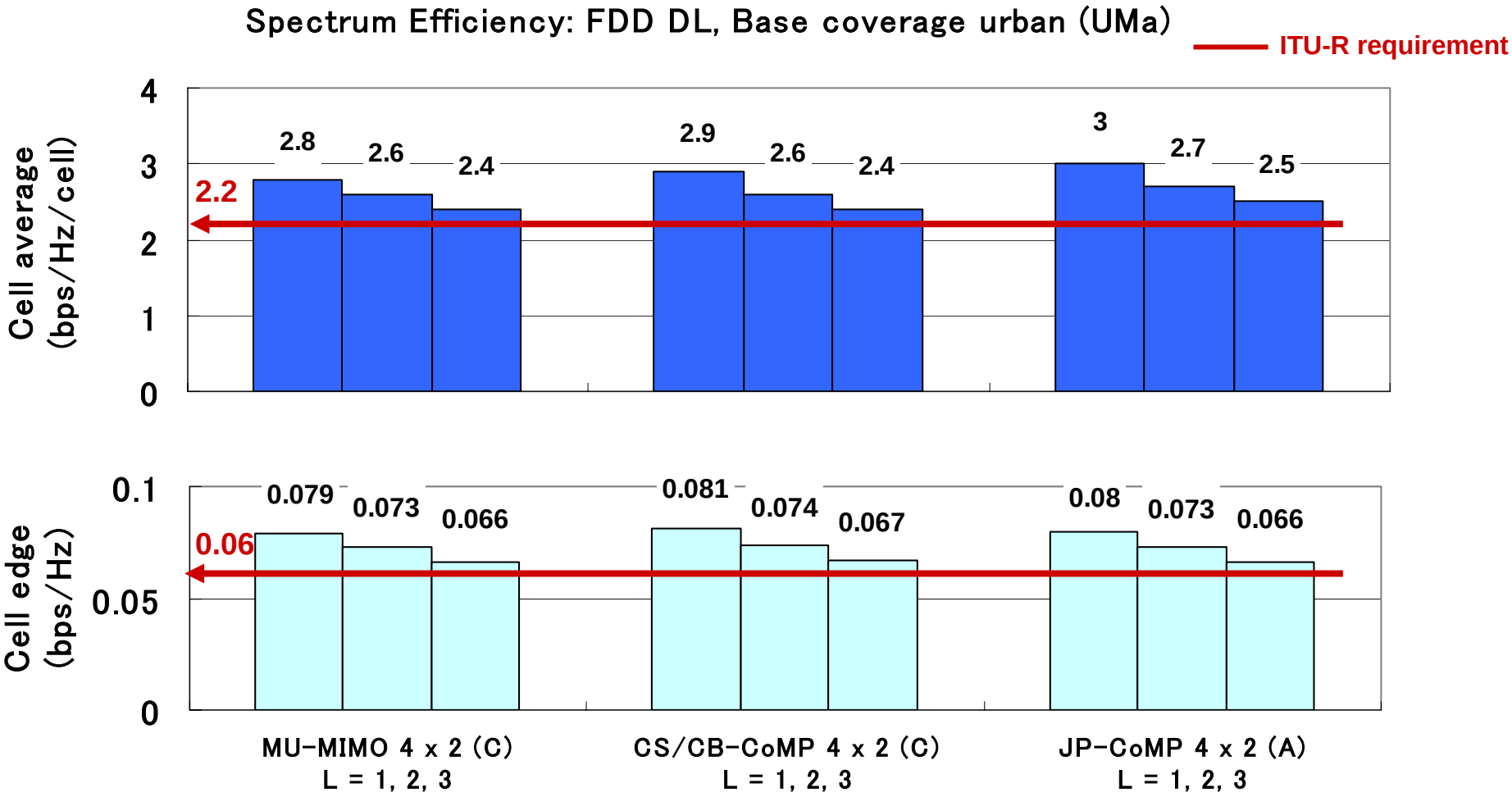


3.3 Base coverage urban (UMa) results

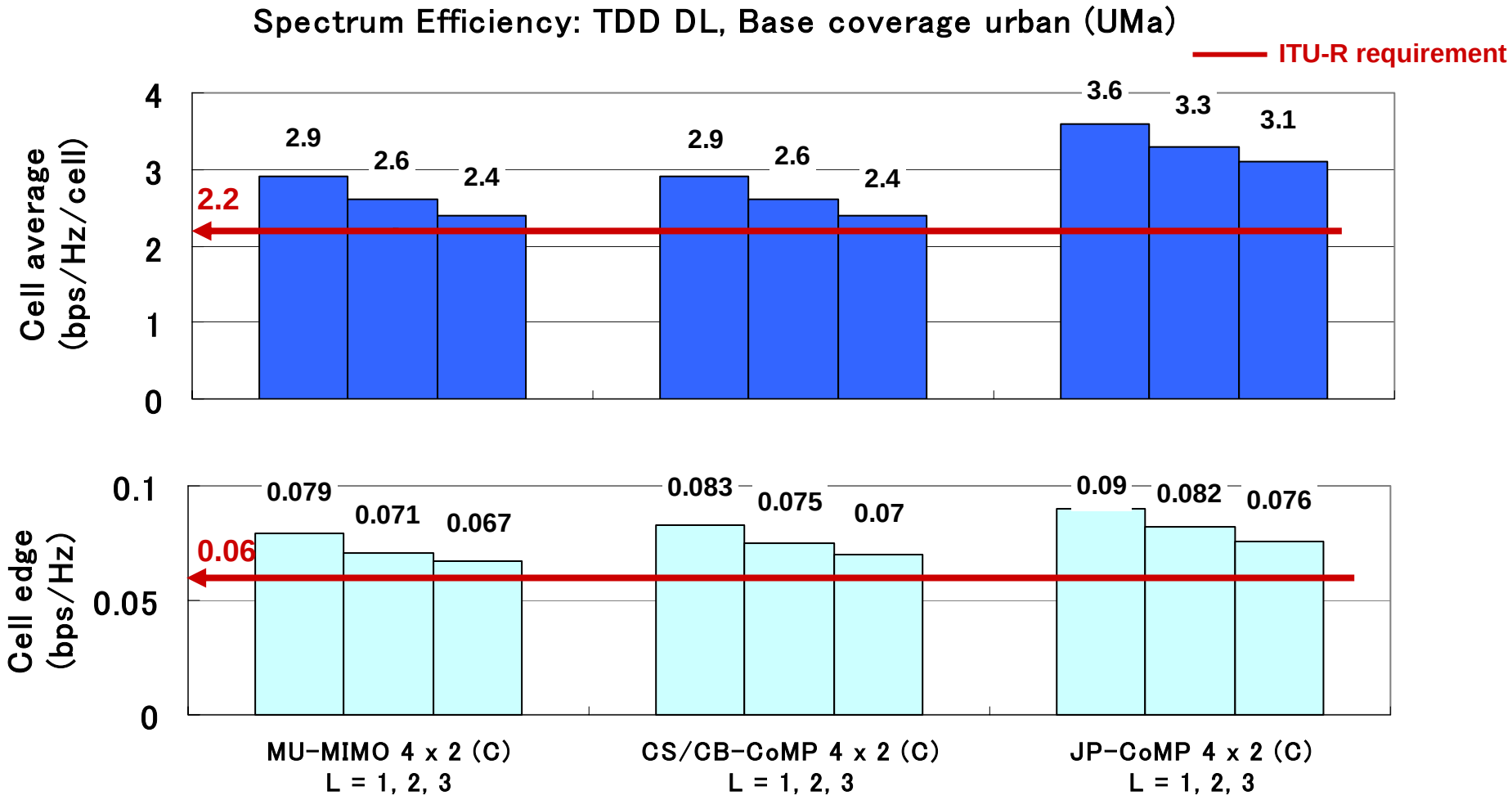
3.3 Base coverage urban environment (Downlink, FDD)

- **Extension of LTE Rel. 8 with MU-MIMO 4x2 (even with maximum DL control overhead (L = 3)) fulfills ITU-R requirements**
- **Further improved performance can be achieved by using additional technology features (e.g., CS/CB-CoMP 4x2, JP-CoMP 4x2)**



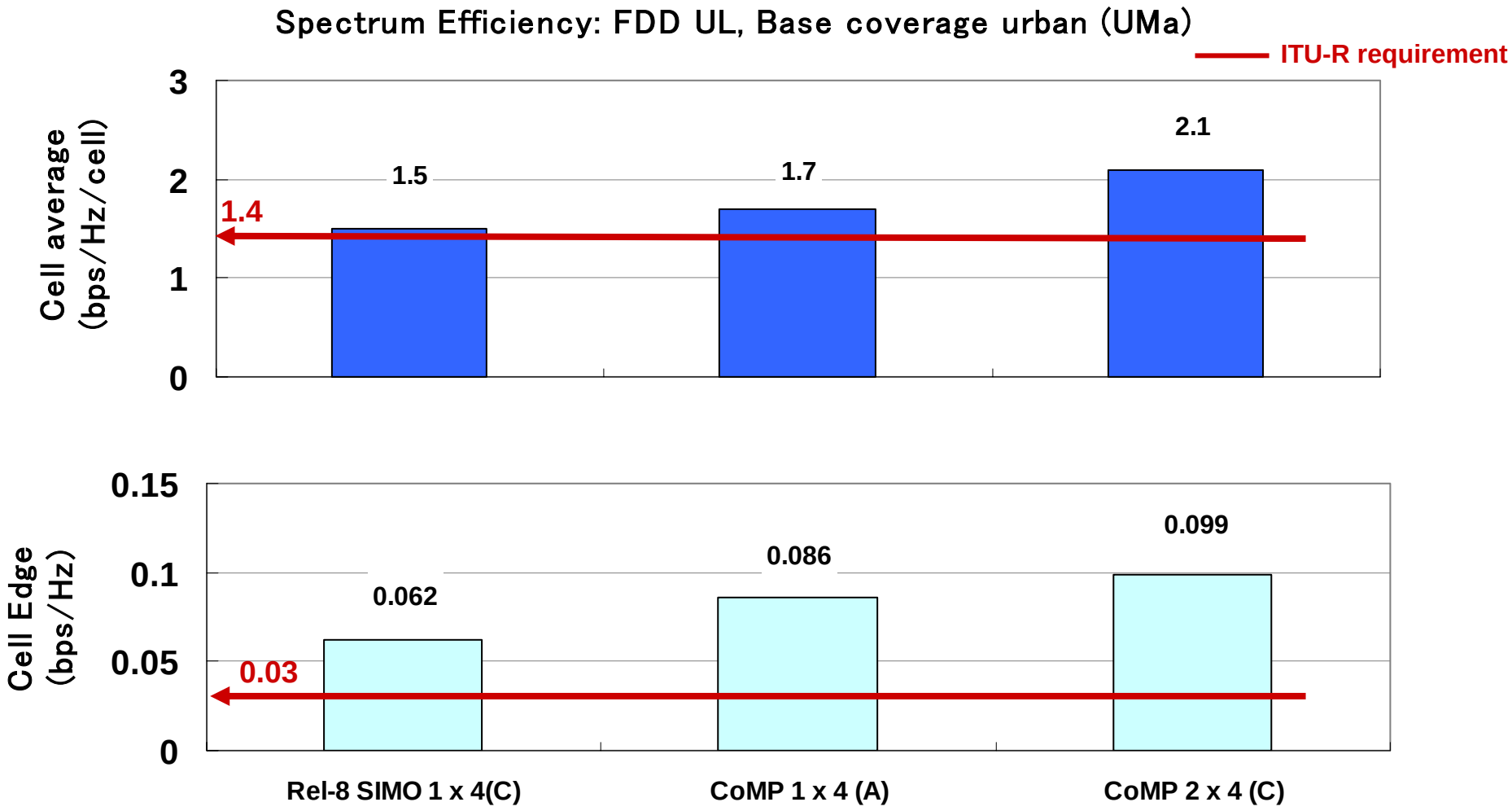
3.3 Base coverage urban environment (Downlink, TDD)

- **Extension of LTE Rel. 8 with MU-MIMO 4x2 (even with maximum DL control overhead (L = 3)) fulfills ITU-R requirements**
- **Further improved performance can be achieved by using additional technology features (e.g., CS/CB-CoMP 4x2, JP-CoMP 4x2)**



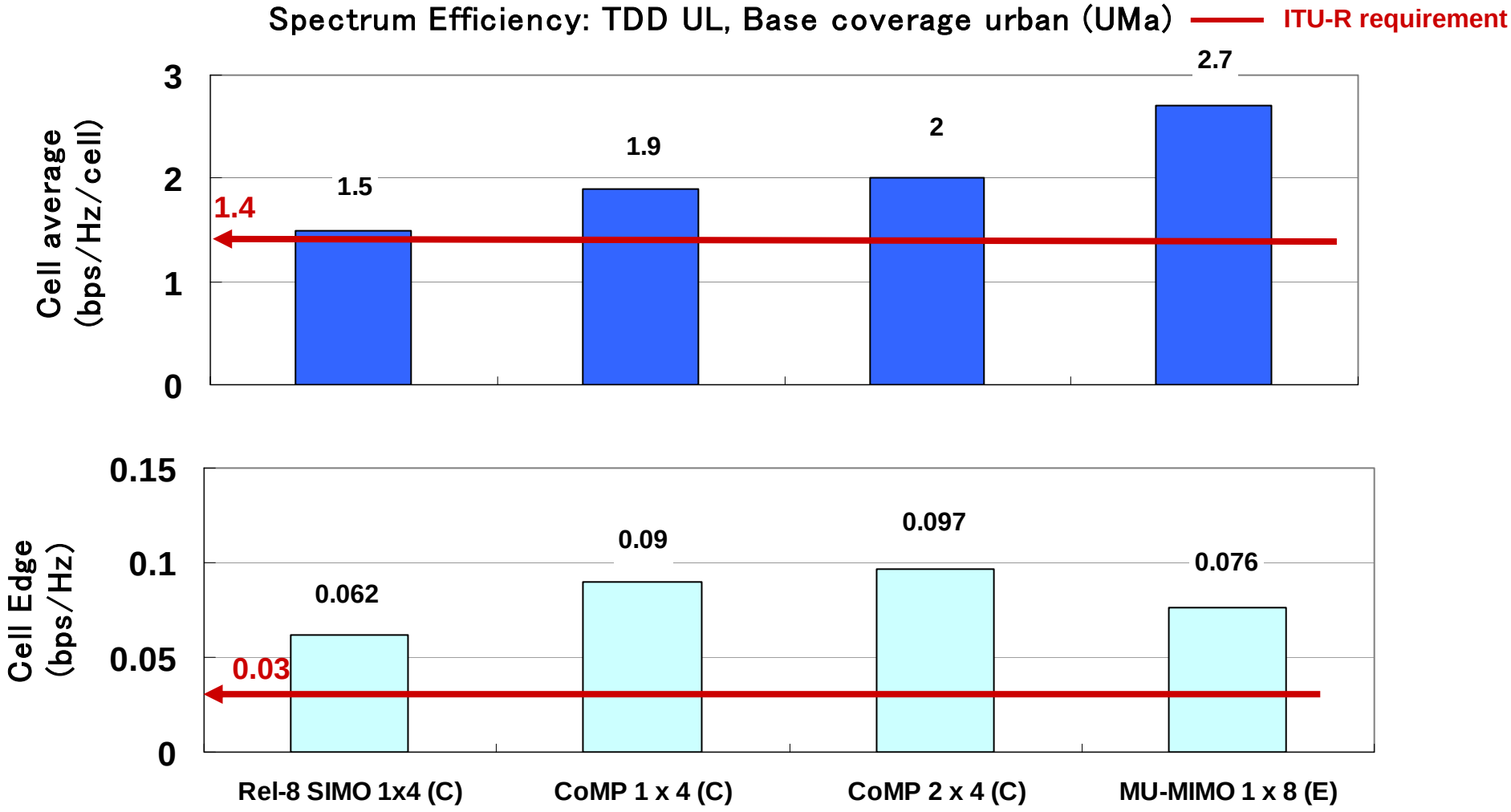
3.3 Base coverage urban environment (Uplink, FDD)

- LTE Rel. 8 with SIMO 1x4 fulfills ITU-R requirements
- Further improved performance can be achieved by using additional technology features (e.g., CoMP 1x4, CoMP 2x4)



3.3 Base coverage urban environment (Uplink, TDD)

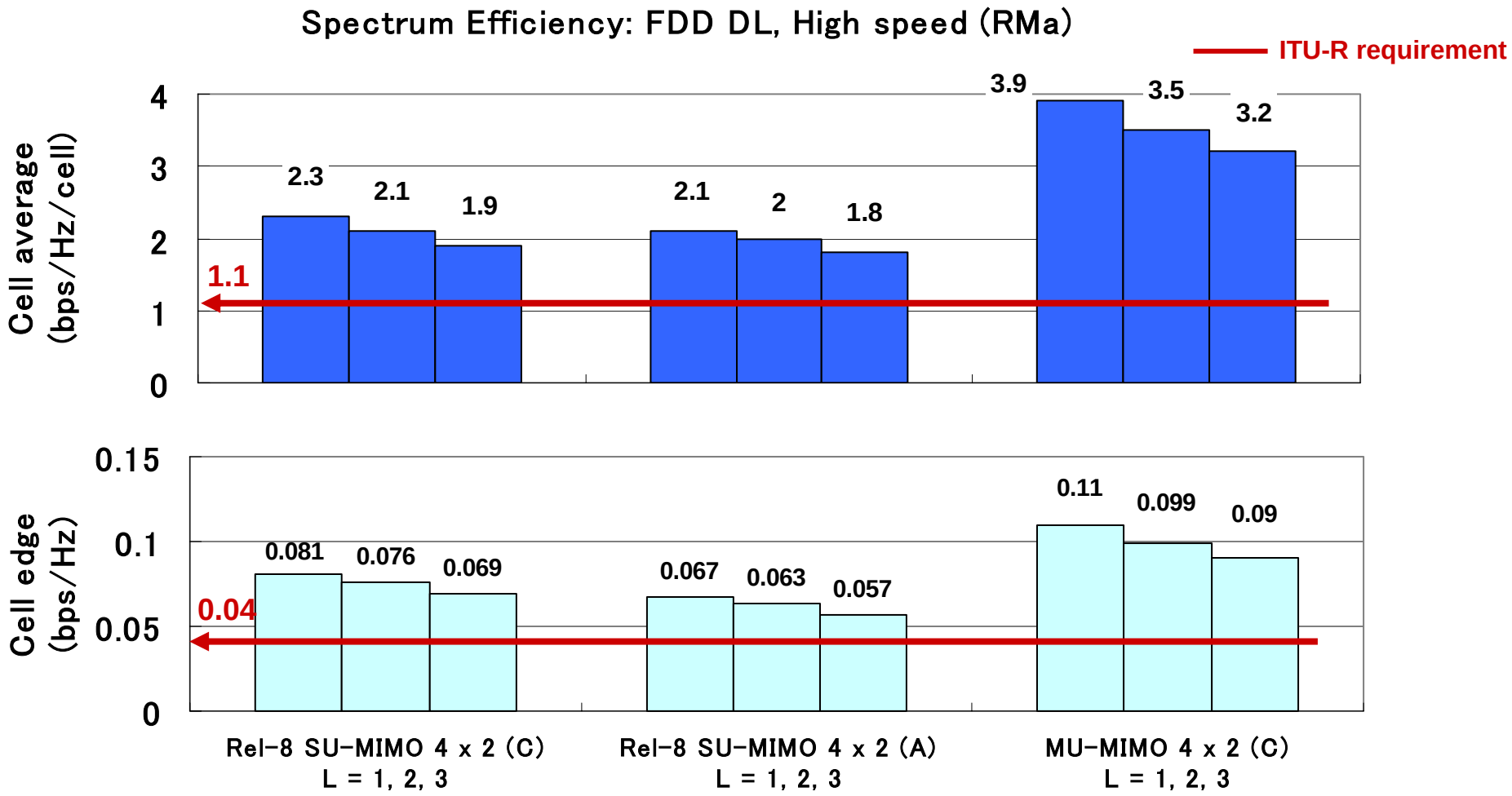
- **LTE Rel. 8 with SIMO 1x4 fulfills ITU-R requirements**
- **Further improved performance can be achieved by using additional technology features (e.g., CoMP 1x4, CoMP 2x4)**



3.4 High speed (RMa) results

3.4 High Speed Environment (Downlink, FDD)

- LTE Rel. 8 with SU-MIMO 4x2 (even with maximum DL control overhead (L = 3)) fulfills ITU-R requirements
- Further improved performance can be achieved by using additional technology features (e.g., MU-MIMO 4x2)



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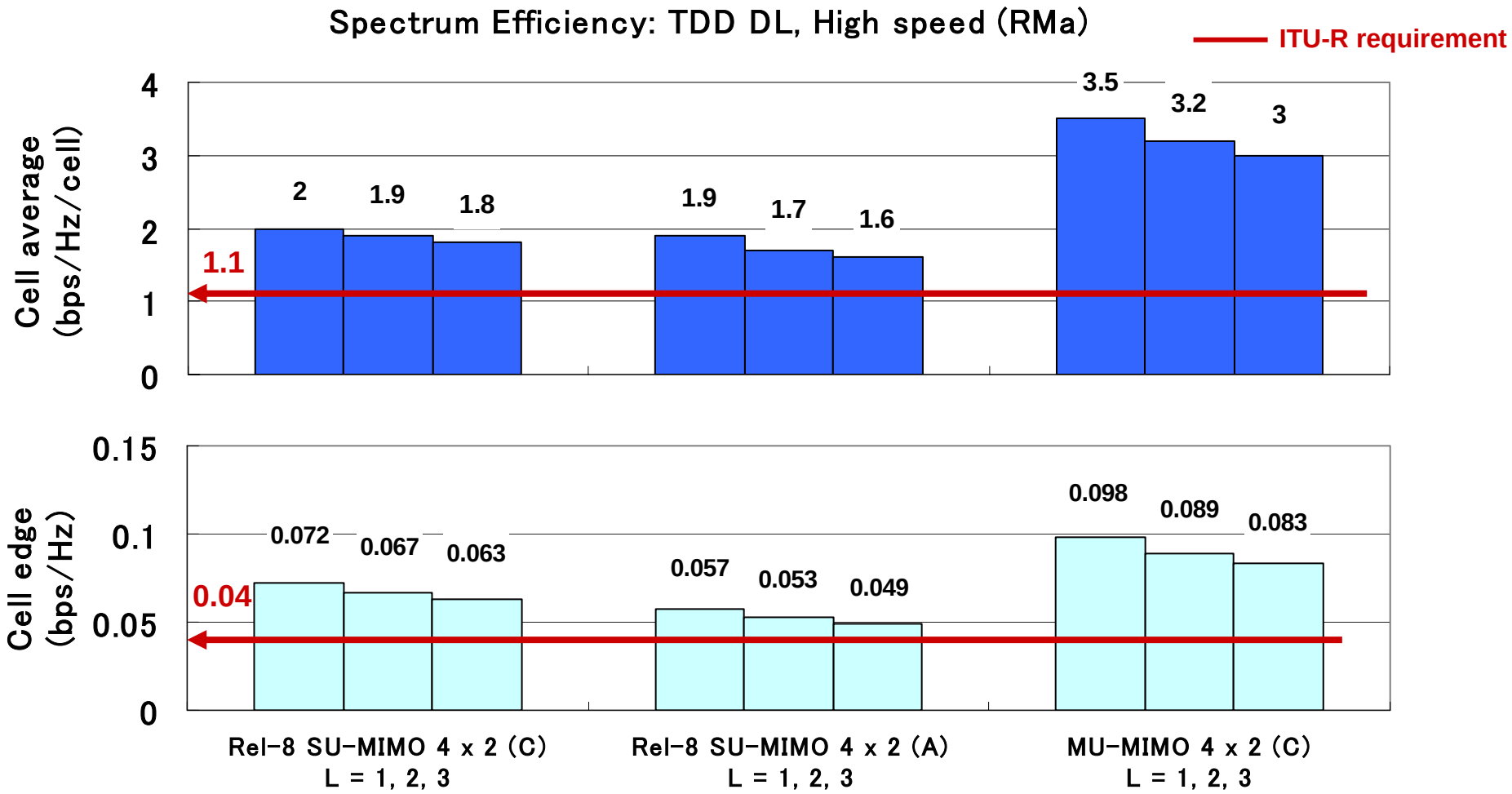
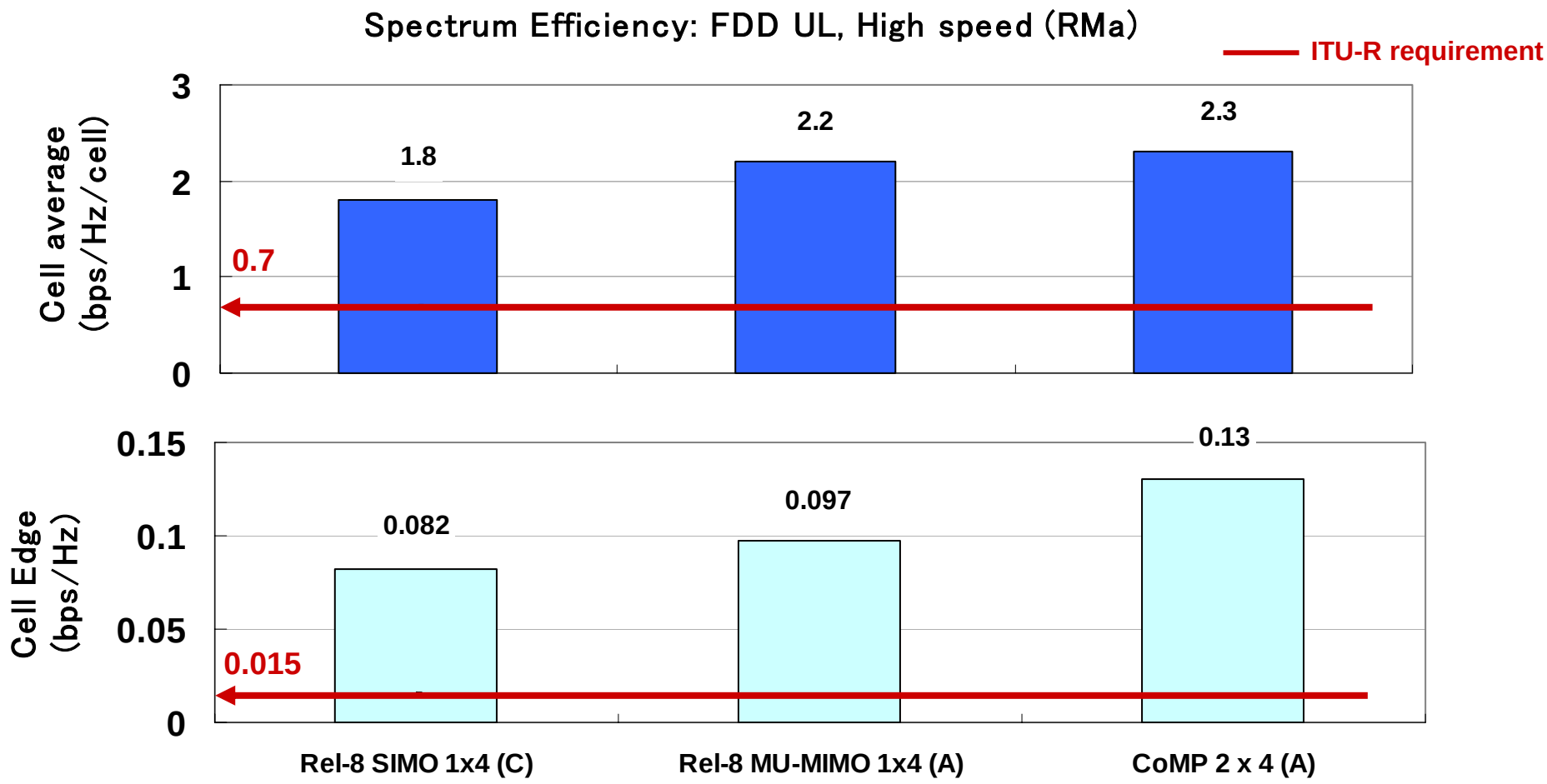


3.4 High Speed Environment (Uplink, FDD)

- LTE Rel. 8 with SIMO 1x4 fulfills ITU-R requirements
- Further improved performance can be achieved by using additional technology features (e.g., Rel-8 MU-MIMO 1x4, CoMP 2x4)



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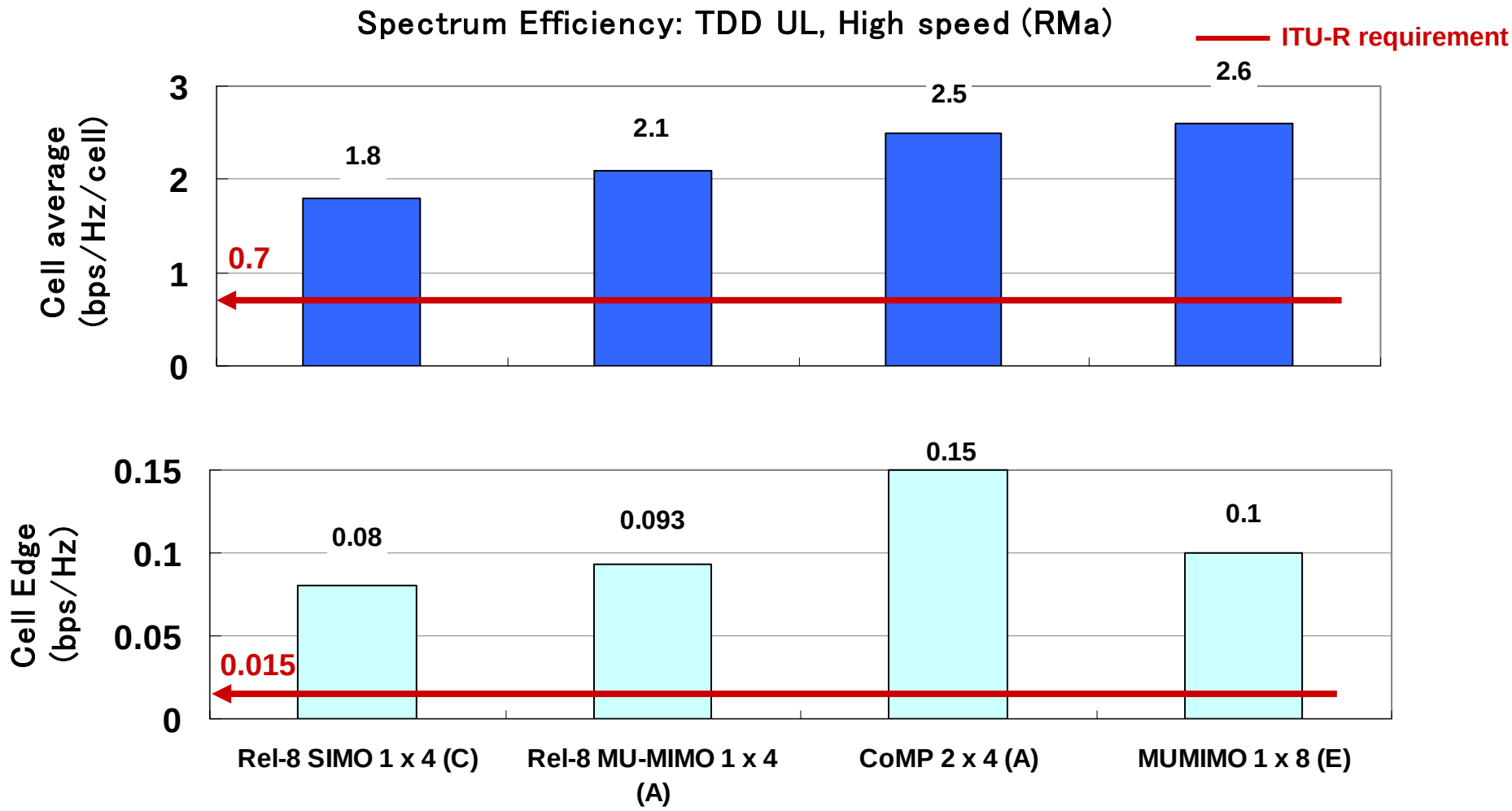

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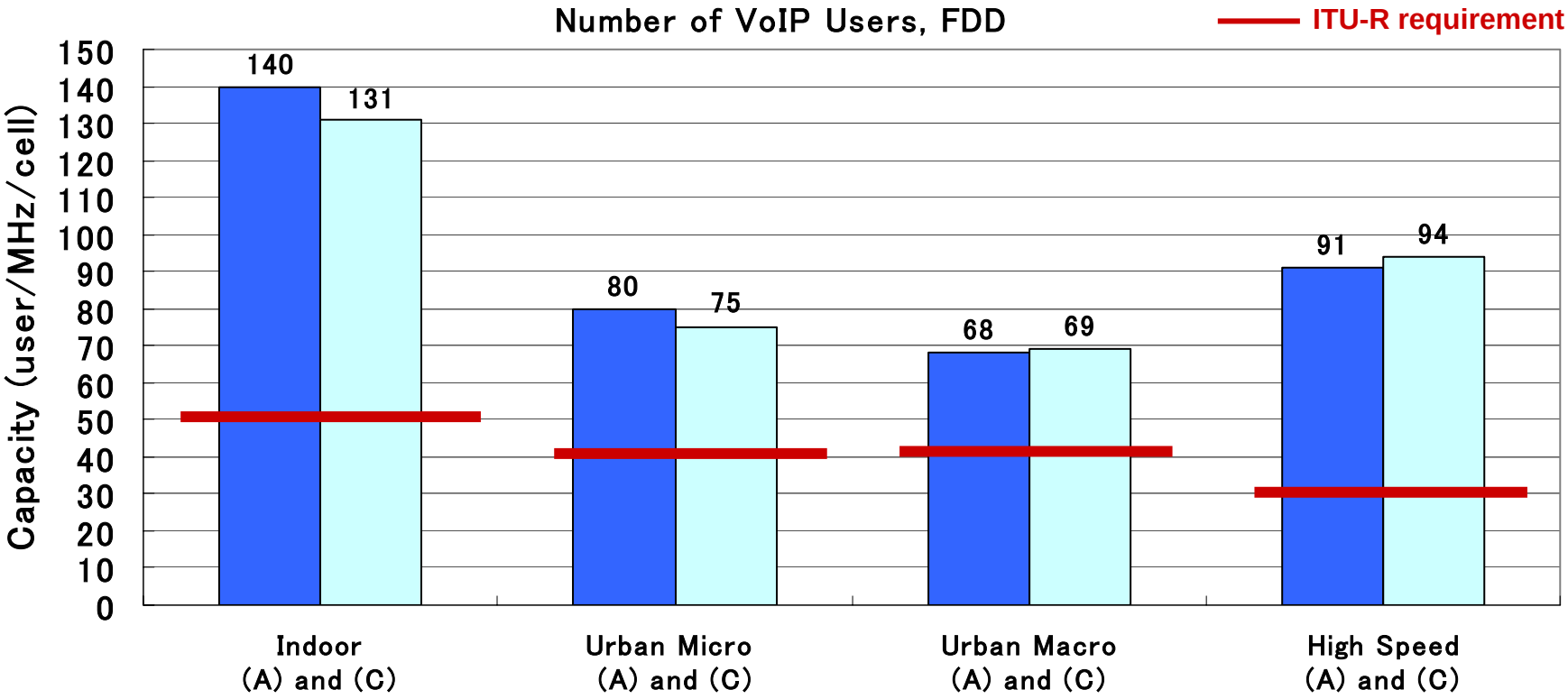
4.1 VoIP results (FDD)

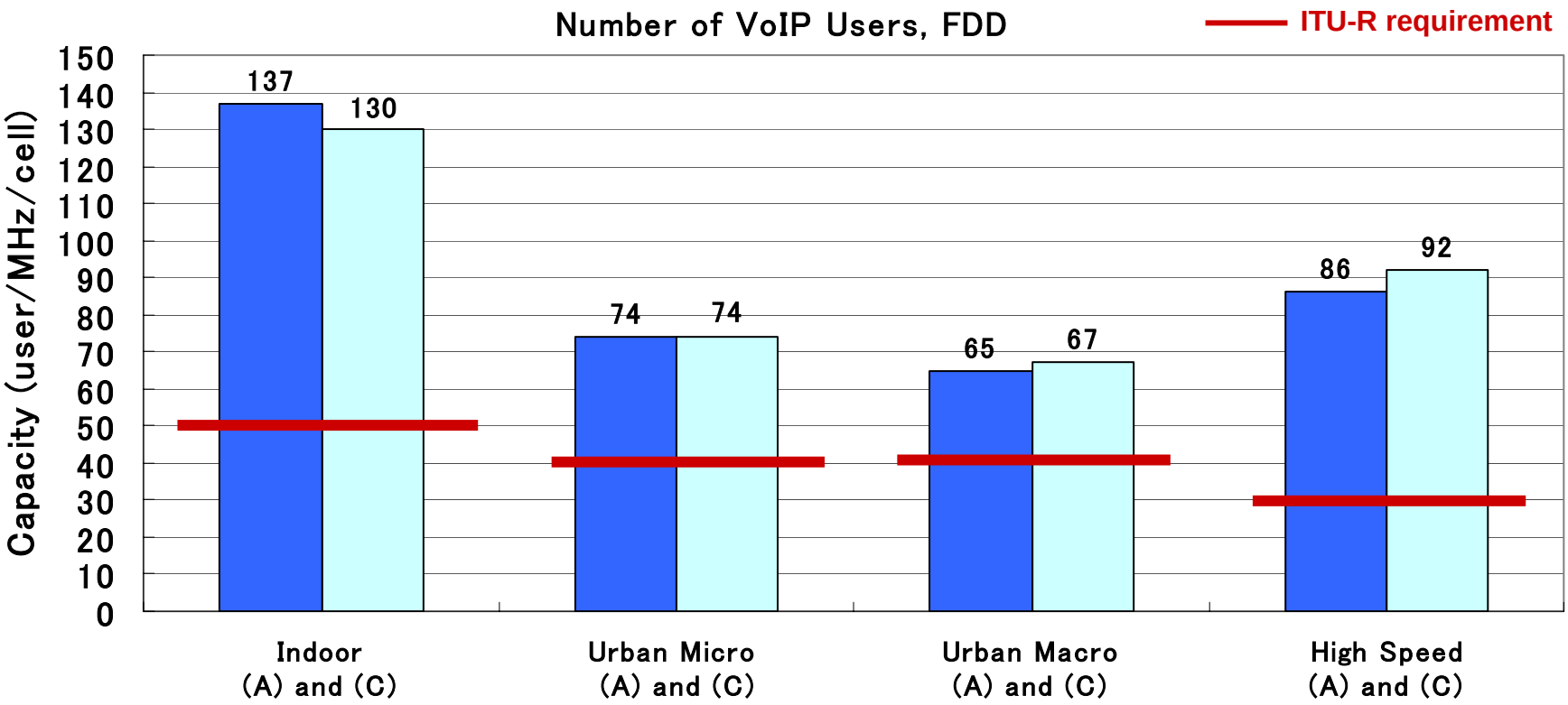
- LTE Rel. 8 fulfills ITU-R requirements for all the environments



Evaluated schemes
DL: Rel. 8 (4x2, 1x2)
UL: Rel. 8 (1x4)

4.2 VoIP results (TDD)

- LTE Rel. 8 fulfills ITU-R requirements for all the environments



Evaluated schemes
DL: Rel. 8 (4x2 or 1x2)
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5.1 Mobility results (FDD)

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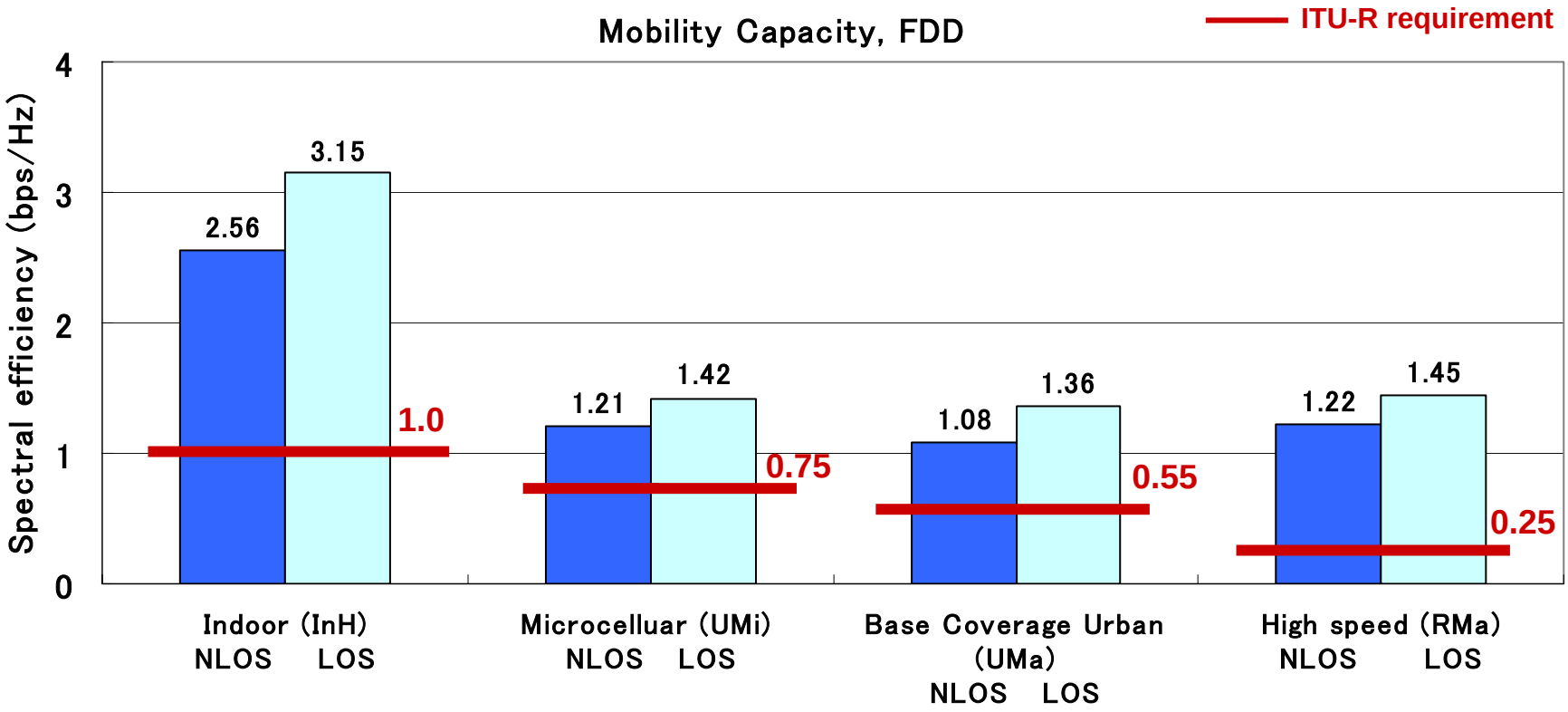
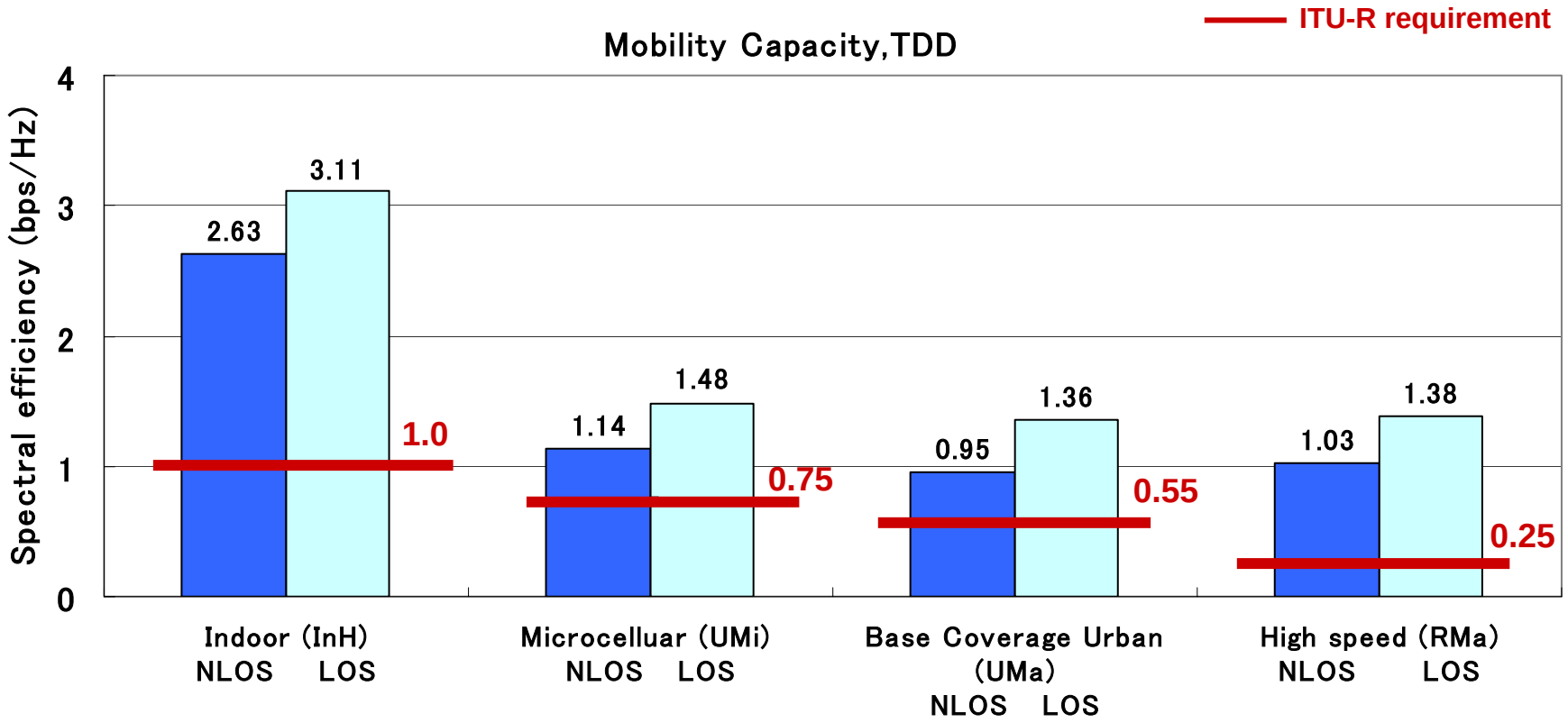


Evaluated schemes
Rel. 8 UL (1x4)

5.2 Mobility results (TDD)

- LTE Rel. 8 fulfills ITU-R requirements for all the environments



Evaluated schemes
Rel. 8 UL (1x4)

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6 Simulator calibration

How to reproduce 3GPP results?

Recommended simulator calibration procedures

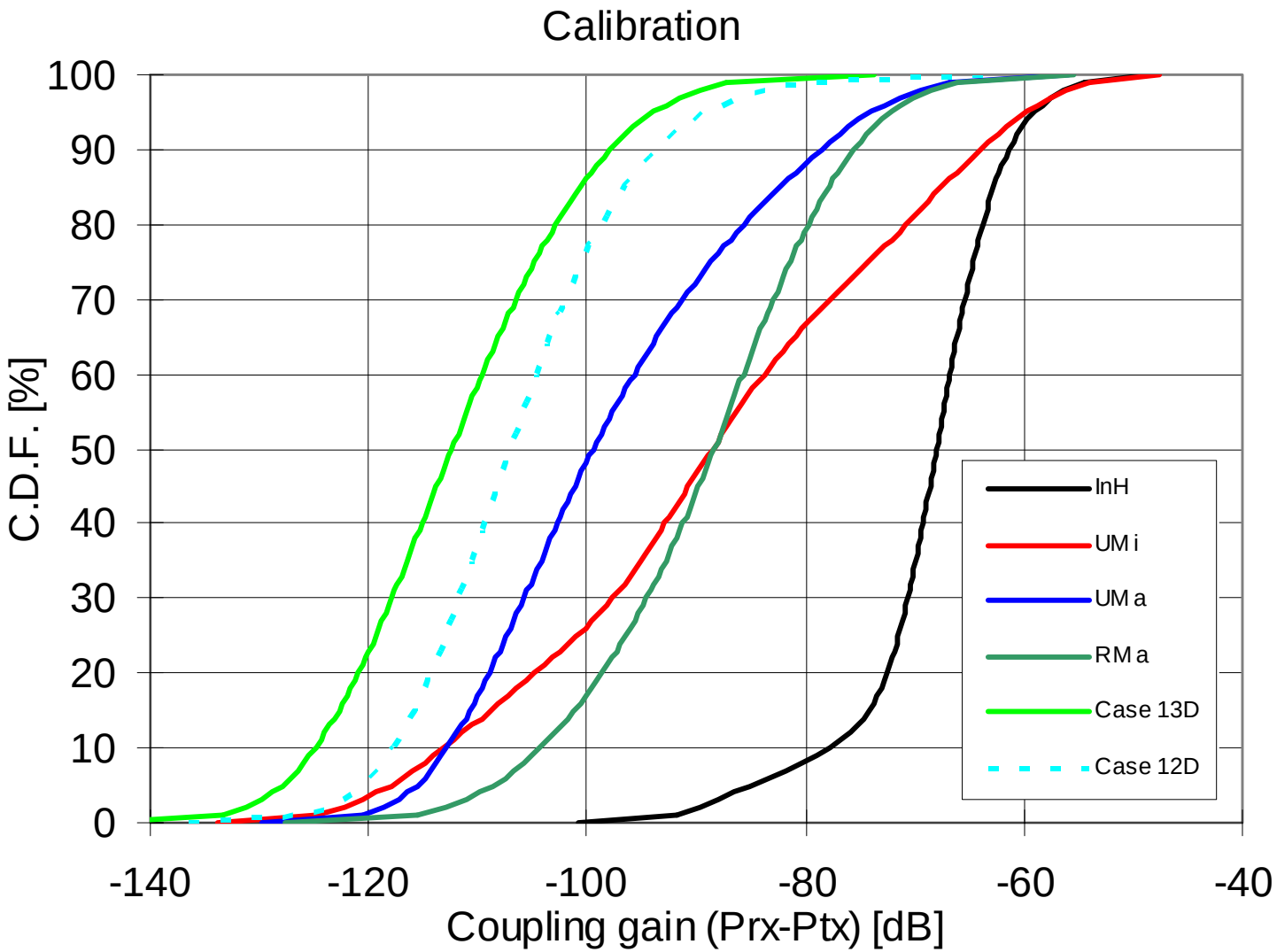
Step 1: Implement ITU-R environments
→ Check that pathloss and geometry distributions are in line with 3GPP results

Step2: Implement basic LTE models (1 x 2)
→ Check that spectral efficiency and user-throughput are in line with 3GPP results

Step3: Implement Rel-8 functionality (DL 4 x 2 SU-MIMO, UL 1 x 4 SIMO)
→ Check that Rel-8 performance is in line with 3GPP results
→ This should enable reaching most ITU-R requirements

Step4: Implement advanced LTE functionality
→ Check that remaining ITU requirements can be reached

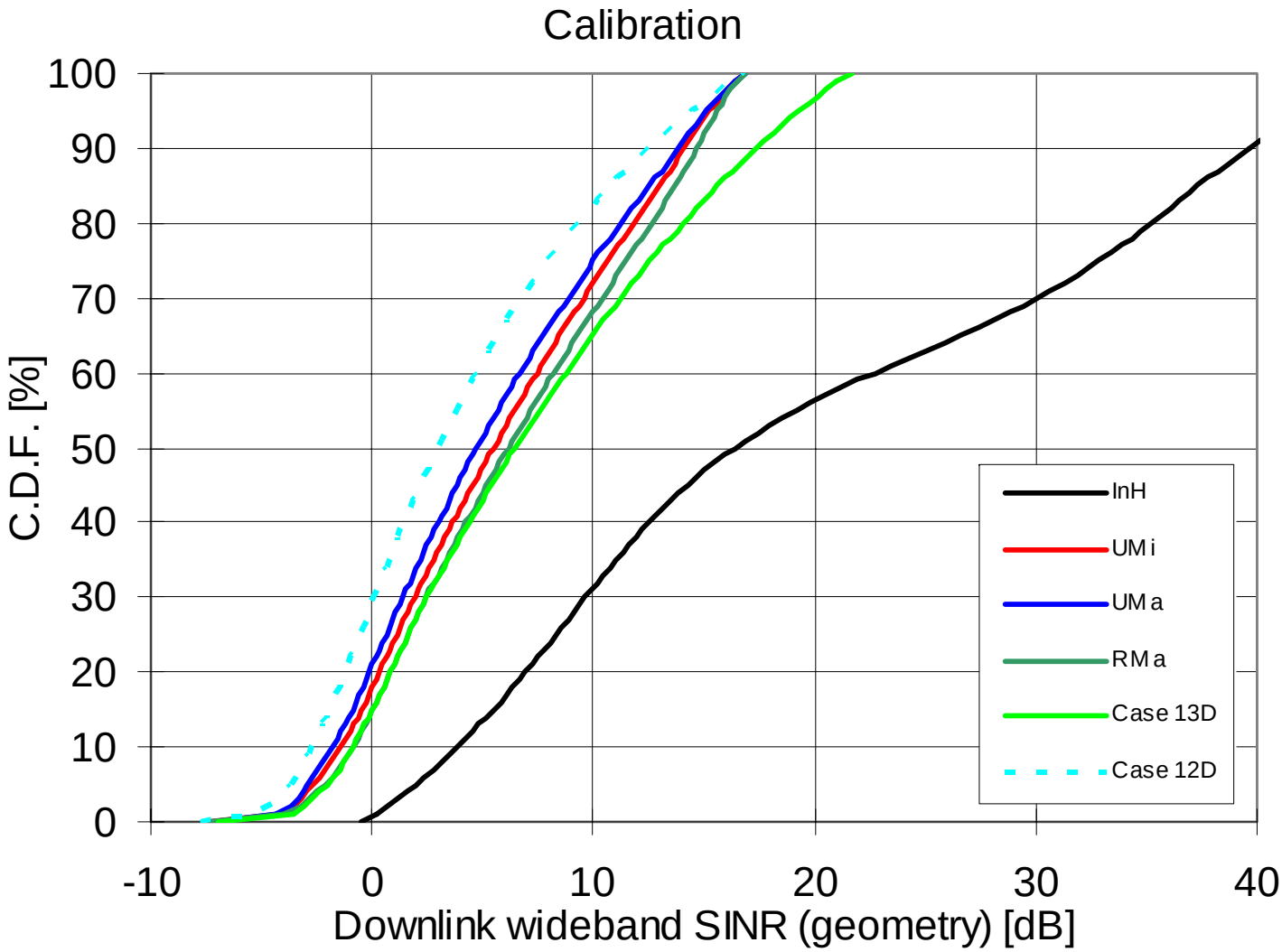
6 Simulator calibration
Step1 results: Coupling gain



Ref: 3GPP TR36.814 ver 1.5.0

Averaged over 17 sources

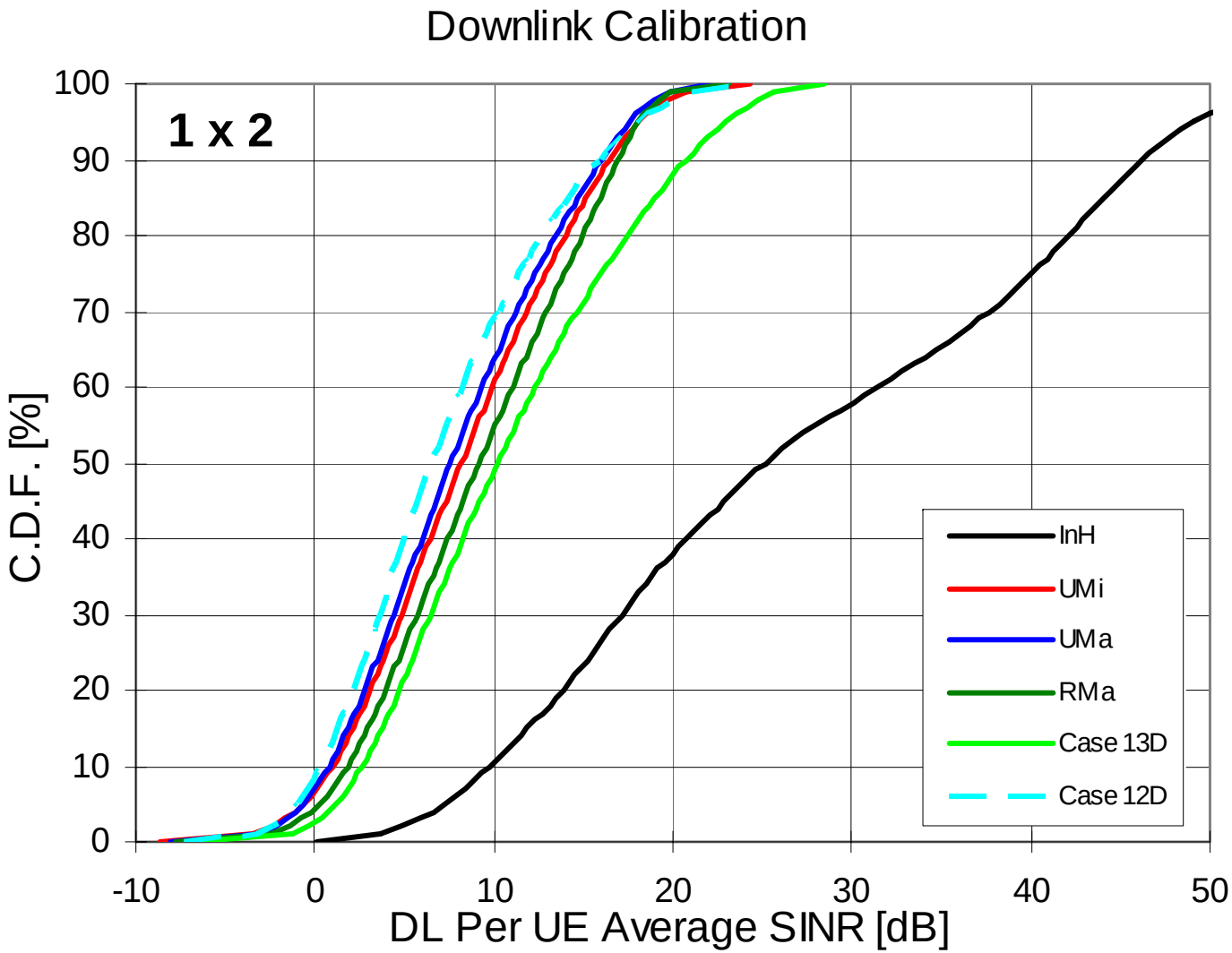
6 Simulator calibration
Step1 results: DL wideband SINR (Geometry)



Ref: 3GPP TR36.814 ver 1.5.0

Averaged over 17 sources

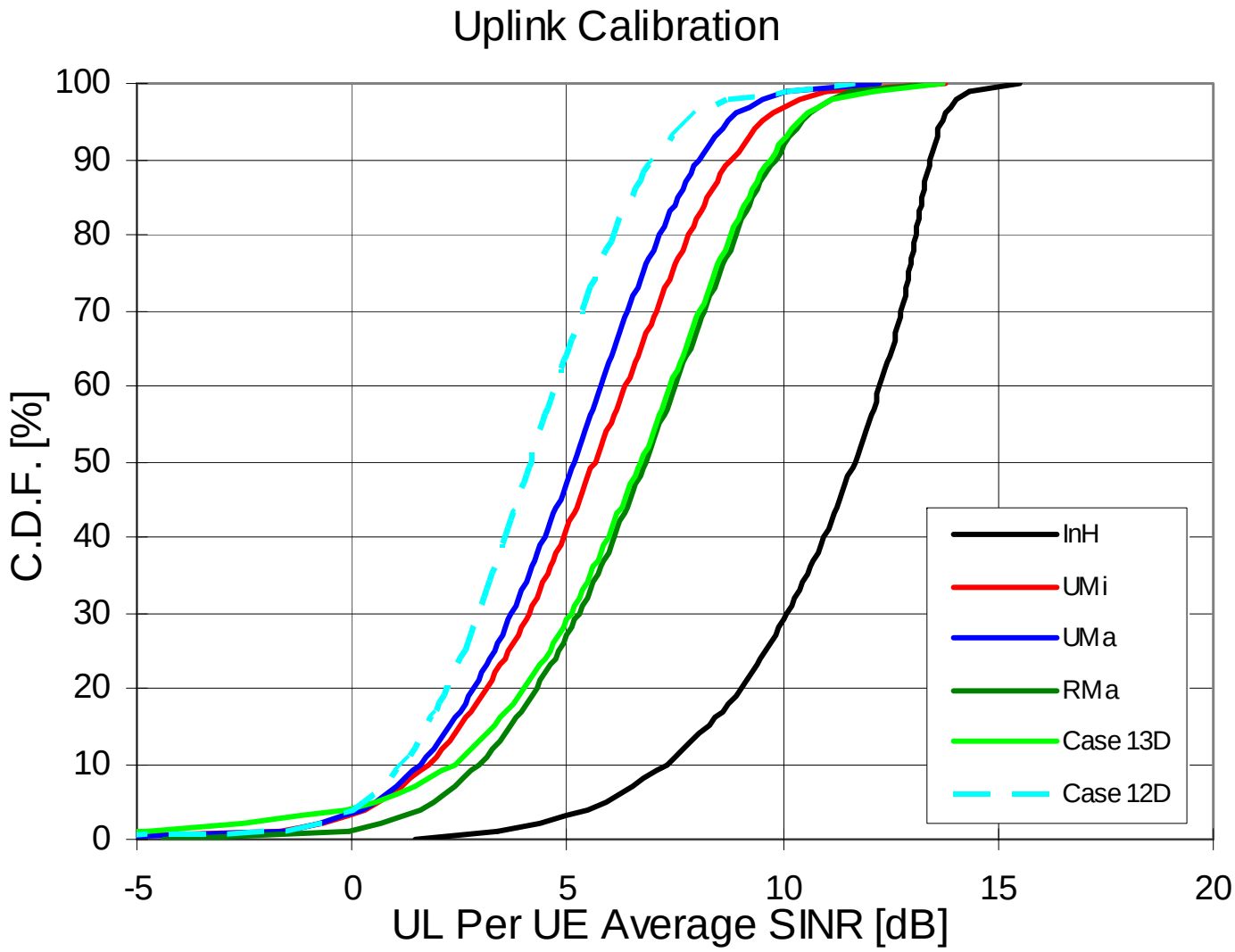
6 Simulator calibration
Step 1 results: DL per UE SINR after MRC combining



Ref: 3GPP TR36.814 ver 1.5.0

Averaged over 16 sources

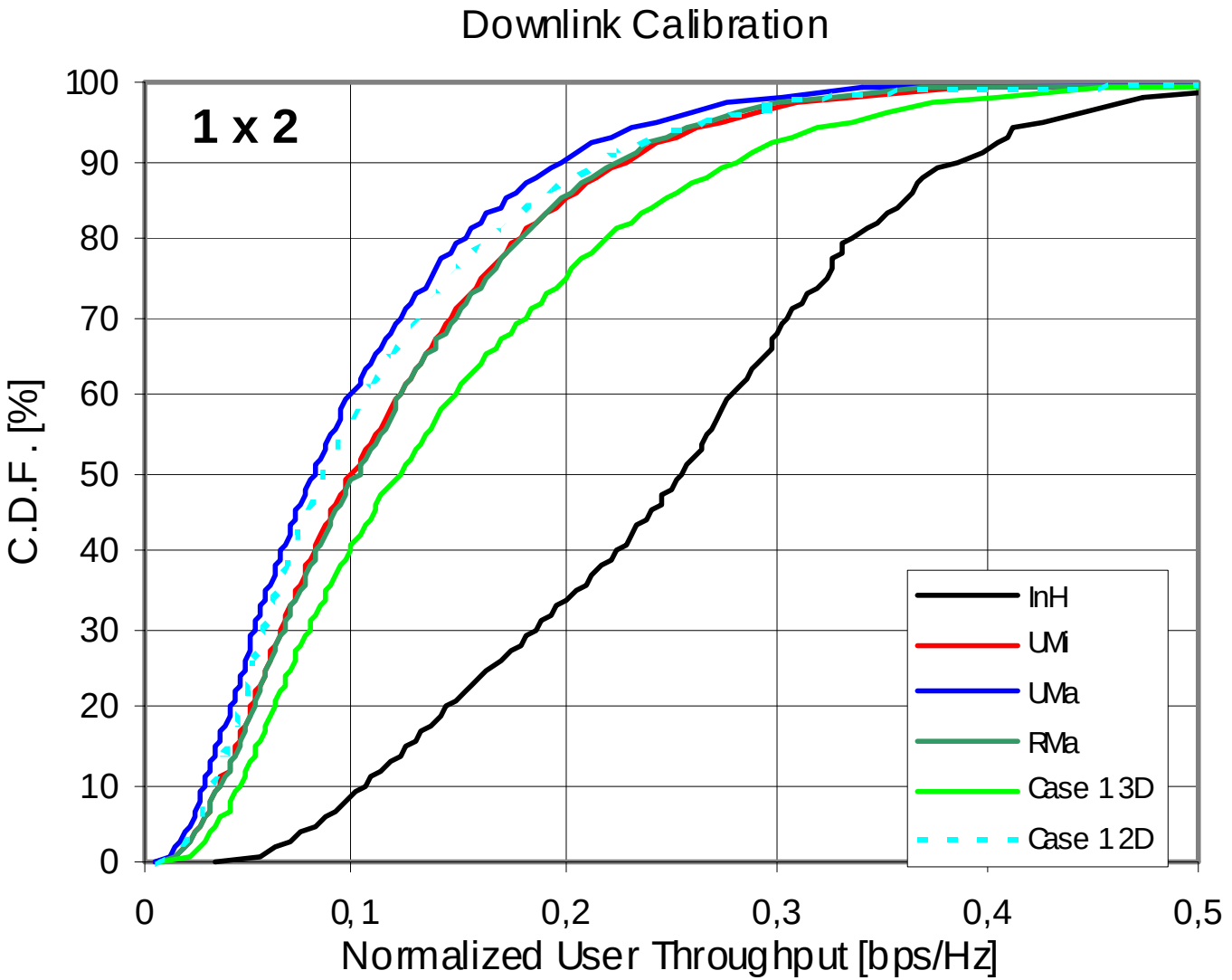
6 Simulator calibration
Step 1 results: UL per UE SINR



Ref: 3GPP TR36.814 ver 1.5.0

Averaged over 16 sources

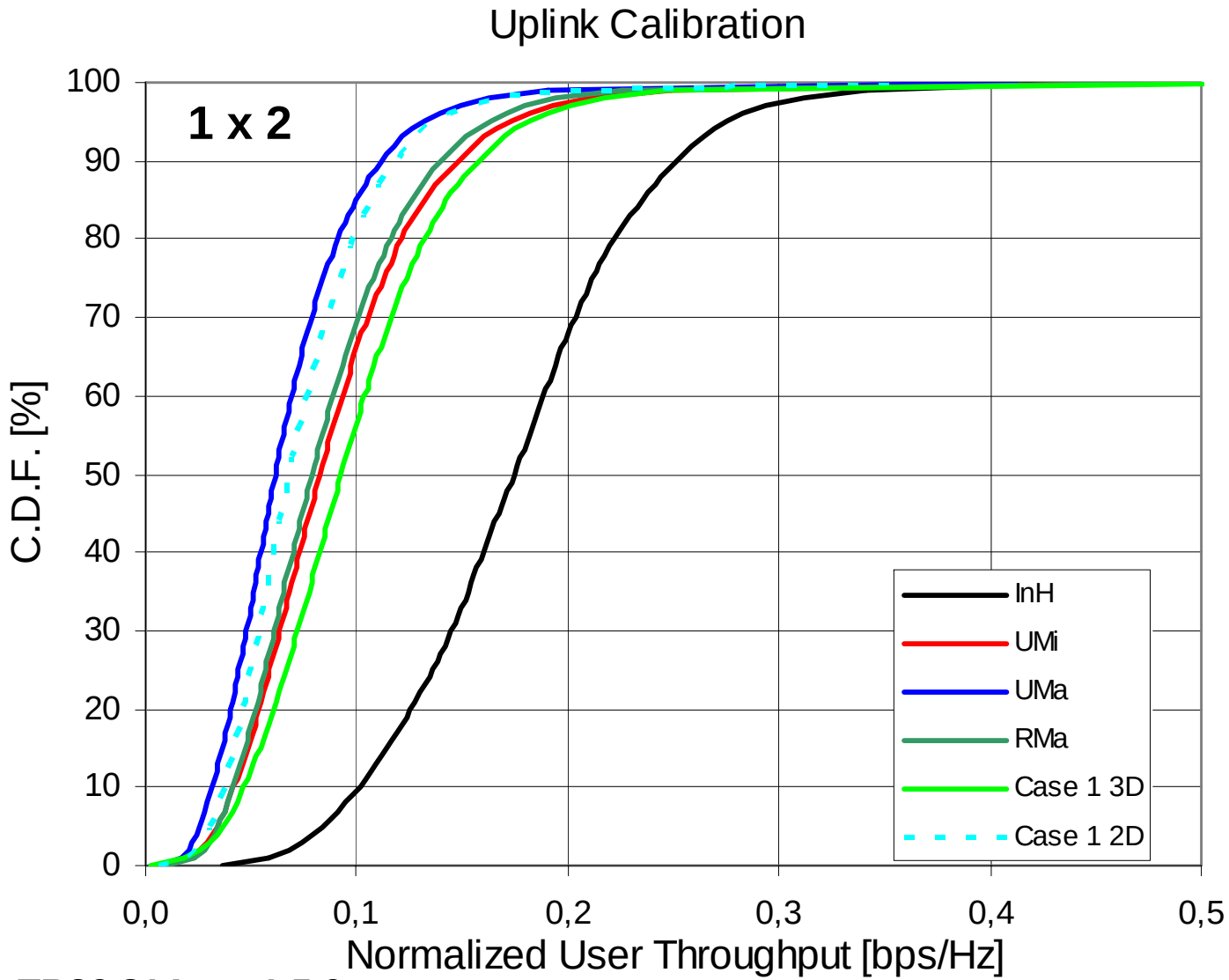
6 Simulator calibration
Step 2 results: DL user throughput



Ref: 3GPP TR36.814 ver 1.5.0

Averaged over 16 sources

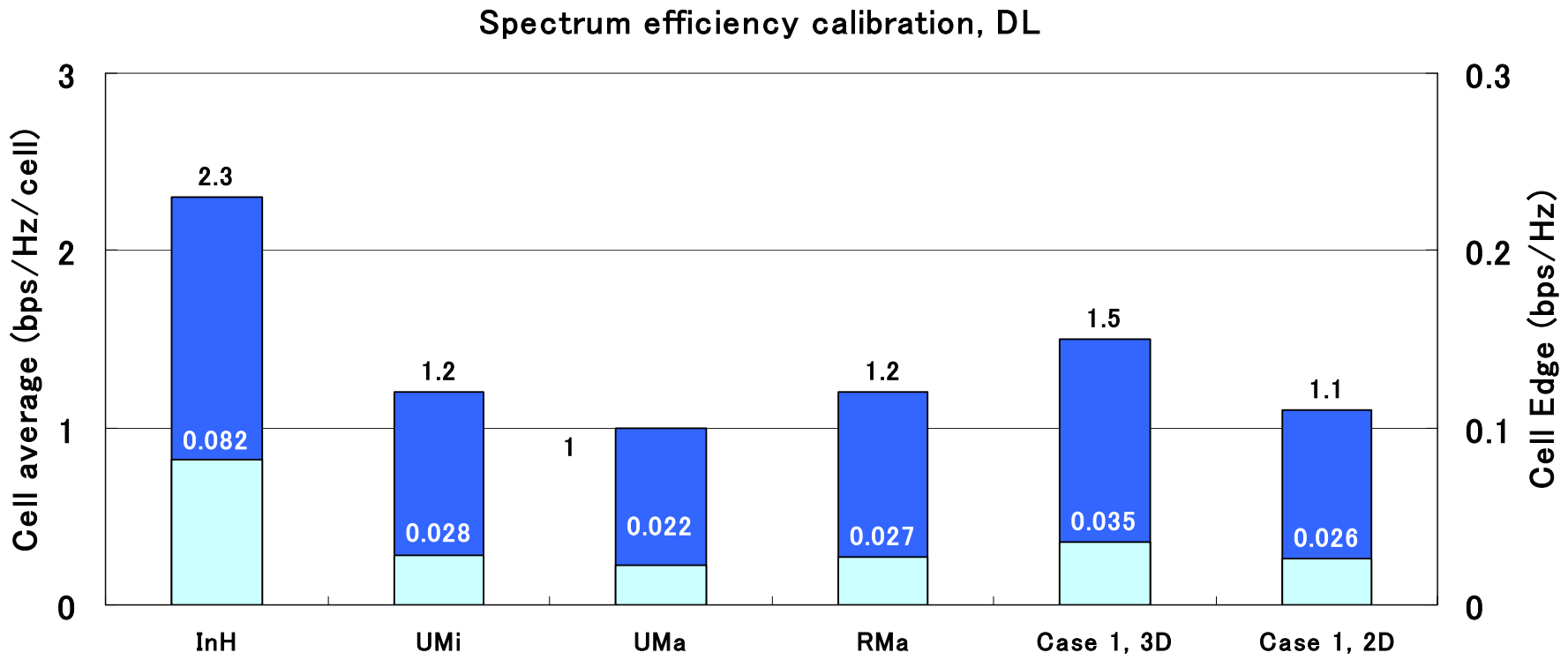
6 Simulator calibration
Step2 results: UL user throughput



Ref: 3GPP TR36.814 ver 1.5.0

Averaged over 16 sources

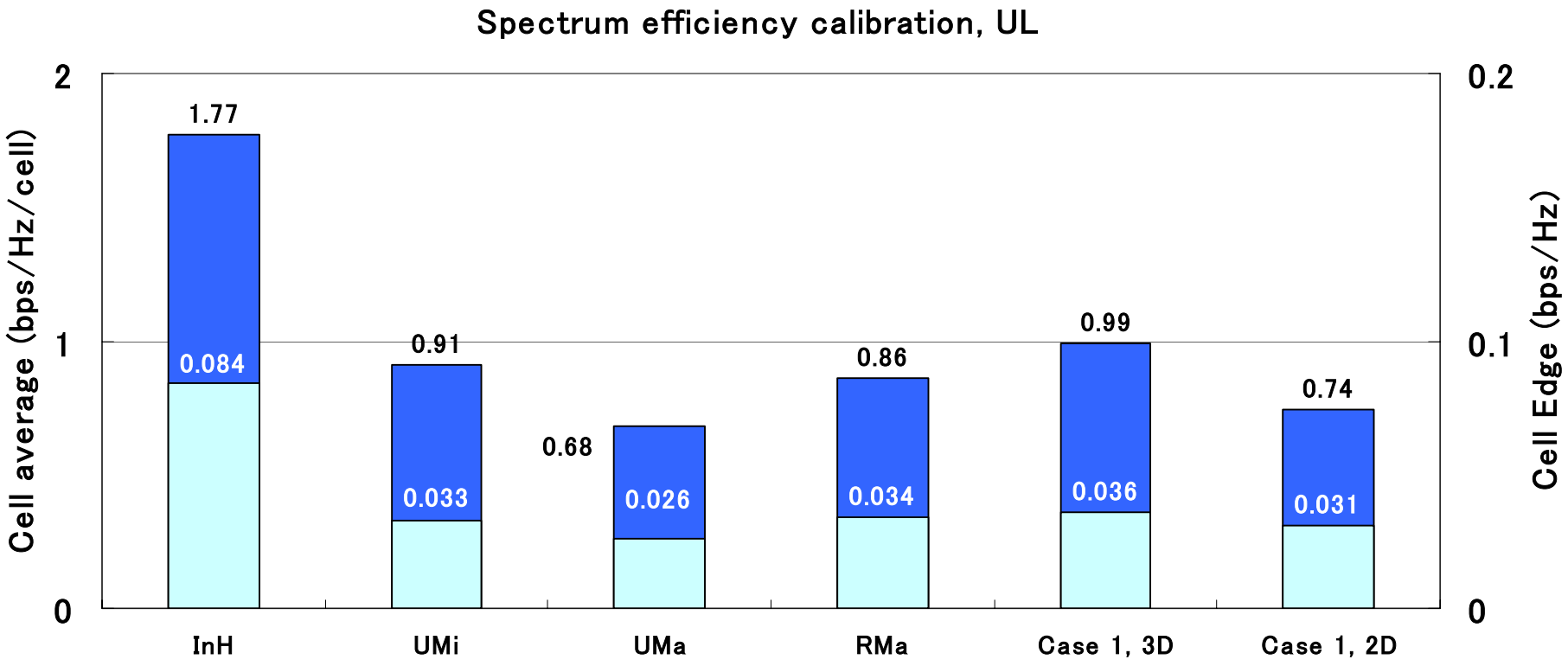
6 Simulator calibration
Step 2 results: DL Spectrum efficiency 1-by-2



Averaged over 16 sources

Ref: 3GPP TR36.814 ver 1.5.0

6 Simulator calibration
Step 2 results: UL spectrum efficiency 1-by-2



Averaged over 16 sources

Ref: 3GPP TR36.814 ver 1.5.0

6 Simulator calibration
Step 3 and 4 results

Results shown in Slide 13 - 31

6 Simulator calibration: parameters (1)

Parameter	Value
Duplex method	FDD
Downlink transmission scheme	1x2 SIMO
Downlink scheduler	Round robin with full bandwidth allocation
Downlink link adaptation	Wideband CQI, no PMI on PUCCH (mode 1-0) 5ms periodicity, 6ms delay total (measurement in subframe n is used in subframe n+6) CQI measurement error: None MCSs based on LTE transport formats [TR36.213]
Downlink HARQ	Maximum four transmissions
Downlink receiver type	MRC
Uplink transmission scheme	1x2 SIMO
Uplink scheduler	Frequency Domain Multiplexing – non-channel dependent, share available bandwidth between users connected to the cell, all users get resources in every uplink subframe. With M users and Nrb PRBs available, Mh=mod(Nrb,M) users get floor(Nrb/M)+1 PRBs whereas Ml=M-Mh users get floor(Nrb/M) PRBs
Uplink Power control	P0 = -106dBm, alpha = 1.0
Uplink Link adaptation	Based on delayed measurements. Ideal channel estimate from UL transmission in subframe n can be used for rate adaptation in subframe n+7 MCSs based on LTE transport formats [TR36.213]
Uplink HARQ	Maximum four transmissions Proponent to specify IR or CC
Uplink receiver type	MMSE in frequency domain, MRC over antennas (no intercell interference rejection)

6 Simulator calibration: parameters (2)

Parameter	Value
Antenna configuration	Vertically polarized antennas 0.5 wavelength separation at UE, 10 wavelength separation at basestation
Channel estimation	Ideal, both demodulation and sounding
Control Channel overhead, Acknowledgements etc.	LTE: L=3 symbols for DL CCHs, M=4 resource blocks for UL CCH, overhead for demodulation reference signals,
BS antenna downtilt	ITU Indoor, indoor hotspot scenario (InH): N/A ITU Microcellular, urban micro-cell scenario (Umi): 12deg ITU Base coverage urban, Urban macro-cell scenario (Uma): 12deg ITU High speed, Rural macro-cell scenario (Rma): 6 deg Case 1 3GPP 3D: 15 deg Case 1 3GPP 2D: N/A
Feeder loss	0dB, except for the ITU scenarios in step 1a where a feeder loss of 2dB is used.
Channel model	According to ITU for ITU scenarios SCM urban macro high spread for 3GPP case 1
Intercell interference modeling	Explicit

7. Conclusion

- The 3GPP self-evaluation has shown that the LTE Release 10 & beyond (LTE-Advanced) SRIT and the individual FDD RIT and TDD RIT components completely satisfy the criteria of Step 7 and should move forward to Step 8 of the process.
- In particular, the SRIT and the individual FDD RIT and TDD RIT components meet all the requirements in all four of the four defined test environments.
- The evaluation results were based on the rigorous calibration effort.