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FINAL EVALUATION REPORT FROM THE 5G INFRASTRUCTURE ASSOCIATION ON IMT-2020 PROPOSAL IMT-2020/19

This contribution contains in Attachment 1 the Final Evaluation Report from the Independent Evaluation Group 5G Infrastructure Association (http://www.itu.int/oth/R0A0600006E/en). The report contains a detailed analysis of the analytical, inspection and simulation characteristics defined in ITU-R Reports M.2410-0, M.2411-0 and M.2412-0 [1] – [3] using a methodology described in Report ITU-R M.2412-0 [3].

The final report contains analytical, simulation and inspection evaluation results. This report includes updates to the preliminary report, which was submitted to the 33rd meeting on Working Party 5D.

The evaluation targets the RIT proposal contained in IMT-2020/19 (Rev.1)-E [4] (TSDSI RIT).

The attached evaluation report consists of 3 Parts:

- Part I: Administrative Aspects of 5G Infrastructure Association
- Part II: Technical Aspects of the work in 5G Infrastructure Association
- Part III: Conclusion

The report is structured according to the proposed structure in [5].

1 Submitted on behalf of the Independent Evaluation Group 5G Infrastructure Association.

2 This contribution is based on work underway within the research in 5G PPP and 5G Infrastructure Association, see https://5g-ppp.eu/. The views expressed in this contribution do not necessarily represent the 5G PPP.

ATTACHMENT 1

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Part I
Administrative aspects of 5G Infrastructure Association

I-1 Name of the Independent Evaluation Group

The Independent Evaluation Group is called *5G Infrastructure Association*.

I-2 Introduction and background of 5G Infrastructure Association

The 5G Infrastructure Association Independent Evaluation Group was launched by the 5G Infrastructure Association as part of 5G Public Private Partnership (5G PPP) in October 2016 by registration at ITU-R.

The 5G Public Private Partnership (5G PPP) is a sub-research program in Horizon 2020 of the European Commission. 5G Infrastructure Association is representing the private side in 5G PPP and the EU Commission the public side. The Association was founded end of 2013. The Contractual Arrangement on 5G PPP was signed by the EU Commission and representatives of 5G Infrastructure Association in December 2013. 5G PPP is structured in three program phases.

- In Phase 1 from July 1, 2015 to 2017 19 projects researched the basic concepts of 5G systems in all relevant areas and contributed to international standardization (https://5g-ppp.eu/5g-ppp-phase-1-projects/).
- Phase 2 started on June 1, 2017 with 23 projects (https://5g-ppp.eu/5g-ppp-phase-2-projects/). The focus of Phase 2 is on the optimization of the system and the preparation of trials.
- The Phase 3 is implemented with 14 projects (https://5g-ppp.eu/5g-ppp-phase-3-projects/)
  - Part 1: 3 Infrastructure Projects,
  - Part 2: 3 Automotive Projects and
  - Part 3: 8 Advanced 5G validation trials across multiple vertical industries. This phase is addressing the development of trial platforms especially with vertical industries, large scale trials, cooperative, connected and automated mobility, 5G long term evolution as well as international cooperation.

In each phase around 200 organizations are cooperating in the established projects.

The main key challenges of the 5G PPP Program are to deliver solutions, architectures, technologies and standards for the ubiquitous 5G communication infrastructures of the next decade:

- Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010.
- Saving up to 90 % of energy per service provided. The main focus will be in mobile communication networks where the dominating energy consumption comes from the radio access network.
- Reducing the average service creation time cycle from 90 hours to 90 minutes.
- Creating a secure, reliable and dependable Internet with a "zero perceived" downtime for services provision.
- Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people.
- Enabling advanced User controlled privacy.

The Independent Evaluation Group is currently supported by the following 5G PPP Phase 2 projects:

- 5G Essence,
- 5G MoNArch,
- 5G Xcast,
- One 5G and
- To-Euro-5G CSA

and the 5G PPP Phase 3 projects

- 5G Genesis,
- 5G Solutions,
- 5G Tours,
- 5G VINNI,
- Clear5G,
- Full5G CSA,
- Global5G.org CSA

and the 5G Infrastructure Association members

- Huawei,
- Intel,
- Nokia,
- Telenor,
- Turkcell and
- ZTE Wistron Telecom AB

This Evaluation Group is evaluating some of all 16 evaluation characteristics according to Table 2 by means of analytical, inspection and simulation activities in order to perform a full evaluation. For simulation purposes simulators at different Evaluation Group member are used, where different evaluation characteristics are mapped to different simulators. Simulators are being calibrated where needed in order to provide comparable results. Calibration results and the calibration approach are published (c.f. Section I-6) in order to provide this information to the other Independent Evaluation Groups to support the consensus building process in ITU-R WP 5D.

I-3 Method of work

The 5G Infrastructure Association Evaluation Group is organized as Working Group in 5G PPP under the umbrella of the 5G Infrastructure Association. Evaluation activities are executed according to a commonly agreed plan and conducted work through e.g.:

- Physical meetings and frequent telephone conferences where the activities are planned and where action items are given and followed up.
- Frequent email and telephone discussions among partners on detailed issues on an ad-hoc basis.
- File sharing on the web.
- Participation in the ITU-R Correspondence Group dedicated to the IMT-Advanced evaluation topics.

In addition, the Evaluation Group participated in a workshop organized by 3GPP on October 24 and 25, 2018 in Brussels and the ITU-R WP 5D Evaluation Workshop on December 10 and 11, 2019 in Geneva at the 33rd meeting of Working Party 5D. In that workshop the Evaluation Group presented the work method, work plan, channel model calibration status, baseline system calibration assumptions, and available evaluation results.

At and after the ITU-R workshop the Evaluation Group communicated with other Evaluation Groups as well regarding calibration and is making material openly available.

Open issues in the system description were discussed and clarified with TSDSI.

Public information on the calibration work is available at the home page listed in Section I-6.

The assessment of the proponent submission and self-evaluation has been made by analytical, inspection and simulation methods as required in Reports ITU-R M.2410-0 [1], M.2411-0 [2] and M.2412-0 [3], see Table 2 in M.2412-0 [3] in Section 6 for details.

I-4 Administrative contact details

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I-6 Other pertinent administrative information

5G Infrastructure Association and 5G PPP homepage:
https://5g-ppp.eu/5g-ppp-imt-2020-evaluation-group/

This homepage contains public information about e.g. calibration work that the 5G Infrastructure Association has performed in order to ensure reliable simulation results as well as the Final Evaluation Report (after it will become available in February 2020).

Since this Evaluation Report focuses on TSDSI RIT, considering the specific calibration results for 3GPP can be used again to demonstrate this Evaluation Report is valid, calibration files can be found in the following documents:

- System-level calibration results:
  - White paper with description of calibration activities:
  - Matlab calibration files

Adobe Acrobat Document   **Package**

- Link-level calibration results:

Adobe Acrobat Document

I-7 Structure of this Report

This Report consists of 3 Parts:

- Part I: Administrative Aspects of 5G Infrastructure Association
- Part II: Technical Aspects of the work in 5G Infrastructure Association
- Part III: Conclusion

The report is structured according to the proposed structure in [5].

Part II

Technical aspects of the work in 5G Infrastructure Association

II-A What candidate technologies or portions of the candidate technologies this IEG is or might anticipate evaluating?

In this report, final results are presented for the RIT proposals in [4] with a focus on the TDSSI submission to ITU-R by means of analytical, inspection and simulation evaluation. The complete simulation evaluations will be provided in the final evaluation report. Table 1 shows the evaluated proposals.

TABLE 1

Evaluated technology proposals

Nufront		China	Korea	ETSI TC DECT DECT Forum		Nufront	TSDSI
SRIT	RIT			5G NR RIT	DECT2020		
-	-	-	-	-	-	-	✓

Table 2 is summarizing the different evaluation characteristics.

TABLE 2

Summary of evaluation methodologies

Characteristic for evaluation	**High-level assessment method**	**Evaluation methodology in ITU-R Report M.2412-0**	**Related section of Reports ITU-R M.2410-0 and ITU-R M.2411-0**
Peak data rate	Analytical	§ 7.2.2	Report ITU-R M.2410-0, § 4.1
Peak spectral efficiency	Analytical	§ 7.2.1	Report ITU-R M.2410-0, § 4.2
User experienced data rate	Analytical for single band and single layer; Simulation for multi-layer	§ 7.2.3	Report ITU-R M.2410-0, § 4.3
5th percentile user spectral efficiency	Simulation	§ 7.1.2	Report ITU-R M.2410-0, § 4.4
Average spectral efficiency	Simulation	§ 7.1.1	Report ITU-R M.2410-0, § 4.5
Area traffic capacity	Analytical	§ 7.2.4	Report ITU-R M.2410-0, § 4.6
User plane latency	Analytical	§ 7.2.6	Report ITU-R M.2410-0, § 4.7.1
Control plane latency	Analytical	§ 7.2.5	Report ITU-R M.2410-0, § 4.7.2
Connection density	Simulation	§ 7.1.3	Report ITU-R M.2410-0, § 4.8
Energy efficiency	Inspection	§ 7.3.2	Report ITU-R M.2410-0, § 4.9
Reliability	Simulation	§ 7.1.5	Report ITU-R M.2410-0, § 4.10
Mobility	Simulation	§ 7.1.4	Report ITU-R M.2410-0, § 4.11

Mobility interruption time	Analytical	§ 7.2.7	Report ITU-R M.2410-0, § 4.12
Bandwidth	Inspection	§ 7.3.1	Report ITU-R M.2410-0, § 4.13
Support of wide range of services	Inspection	§ 7.3.3	Report ITU-R M.2411-0, § 3.1
Supported spectrum band(s)/range(s)	Inspection	§ 7.3.4	Report ITU-R M.2411-0, § 3.2

II-B Confirmation of utilization of the ITU-R evaluation guidelines in Report ITU-R M.2412

5G Infrastructure Association confirms that the evaluation guidelines provided in Report ITU-R M.2412-0 [3] have been utilized.

II-C Documentation of any additional evaluation methodologies that are or might be developed by the Independent Evaluation Group to complement the evaluation guidelines

The following additional evaluation methodologies have been applied by this Evaluation Group:

- Updating of already available link-level and system-level simulators according to the submitted RITs as well as to ITU-R requirements
- These link-level and system-level simulators have been calibrated with respect to externally available results.

II-D Verification as per Report ITU-R M.2411 of the compliance templates and the self-evaluation for each candidate technology as indicated in A)

The evaluation template is completed in Section III-2. There is little gain for the TSDSI of component RIT compared to 3GPP NR.

II-D-1 Identify gaps/deficiencies in submitted material and/or self-evaluation

There were obvious gaps and deficiencies identified in the submission of TSDSI.

II-E Assessment as per Reports ITU-R M.2410, ITU-R M.2411 and ITU-R M.2412 for each candidate technology as indicated in A)

In the following Sections details are provided on

- Detailed analysis/assessment and evaluation by the IEGs of the compliance templates submitted by the proponents per the Report ITU-R M.2411 section 5.2.4;
- Provide any additional comments in the templates along with supporting documentation for such comments;
- Analysis of the proponent’s self-evaluation by the IEG.

Analytical, inspection evaluation and simulation-based evaluation

II-E-1 5th percentile user spectral efficiency

The ITU-R minimum requirements on 5th percentile user spectral efficiency are given in [1]. The following requirements and remarks are extracted from [1].

TABLE 1

5th percentile user spectral efficiency

Test environment	***Downlink (bit/s/Hz)***	***Uplink (bit/s/Hz)***
Indoor Hotspot – eMBB	*0.3*	*0.21*
Dense Urban – eMBB (NOTE 1)	*0.225*	*0.15*
Rural – eMBB	*0.12*	*0.045*
NOTE 1 – This requirement will be evaluated under Macro TRxP layer of Dense Urban – eMBB test environment as described in Report ITU-R M.2412-0.		

The performance requirement for Rural-eMBB is not applicable to Rural-eMBB LMLC (low mobility large cell) which is one of the evaluation configurations under the Rural- eMBB test environment.

The conditions for evaluation including carrier frequency and antenna configuration are described in Report ITU-R M.2412-0 for each test environment.

The 5th percentile user spectral efficiency (SE) is evaluated by system level simulations. Furthermore, as required in [3], the 5th percentile user spectral efficiency is assessed jointly with the average spectral efficiency using the same simulations. Therefore, the evaluation results of the 5th percentile user spectral efficiency are provided together with average spectral efficiency values in Section II-E.2.

Average spectral efficiency

The ITU-R minimum requirements on average spectral efficiency are given in [1]. The following requirements and remarks are extracted from [1]:

This requirement is defined for the purpose of evaluation in the eMBB usage scenario.

The minimum requirements for average spectral efficiency for various test environments are summarized in Table 2.

TABLE 2

Average spectral efficiency

Test environment	***Downlink (bit/s/Hz/TRxP)***	***Uplink (bit/s/Hz/TRxP)***
Indoor Hotspot – eMBB	*9*	*6.75*
Dense Urban – eMBB (Note 1)	*7.8*	*5.4*
Rural – eMBB	*3.3*	*1.6*
NOTE 1 – This requirement applies to Macro TRxP layer of the Dense Urban – eMBB test		

environment as described in Report ITU-R M.2412-0.

The performance requirement for Rural-eMBB is also applicable to Rural-eMBB LMLC which is one of the evaluation configurations under the Rural- eMBB test environment. The details (e.g. 6 km inter-site distance) can be found in Report ITU-R M.2412-0.

The conditions for evaluation including carrier frequency and antenna configuration are described in Report ITU-R M.2412-0 for each test environment.

II-E.2.1. Technical features for TSDSI

According to RIT proposals in [4], the new technology features differing from 3GPP are summarized as follow. It should be noted that if these features are not applied, the evaluation results would be the same as that submitted by 3GPP.

– *Feature 1: The configuration of resource block group (RBG) size is not determined by bandwidth part size (BWP) size. For 3GPP specification [6], the RBG size is determined by BWP size*

– *Feature 2: Shorter processing time between NZP-CSI-RS and aperiodic SRS is supported, as defined in Table 3. For 3GPP specification [6], the delay is 42 symbols.*

TABLE 3

The delay configuration for SRS precoding

μ (Numerology)	***Delay in number of OFDM symbols***
0	*4*
1	*7*
2	*14*
3	*29*

– *Feature 3: Mandating pi/2 BPSK with spectrum shaping filter and mandating 26 dBm for Pi/2 BPSK. Configurable Tx power for DMRS and data when Pi/2 BPSK is used.*

– *Feature 4: Provide additional phase tracking reference signal (PTRS) density determination.*

In the following sub-sections, the potential performance gain for the above technical features except PTRS enhancement will be evaluated. In sub-6 GHz, PTRS is usually not configured. All PRTS density configurations allowed by TSDSI are also allowed by 3GPP specification, thus no PTRS overhead saving can be achieved by TSDSI compared to 3GPP.

The performance of RBG size configuration and fast SRS precoding is evaluated in Dense Urban – eMBB test environment. For the transmission power enhancement with pi/2 BPSK, the performance is evaluated in Rural – eMBB test environment, to identify the gain for coverage enhancement. The test environments and evaluation configuration parameters are described in [3]. Further evaluation assumptions can be found in Annex A.

II-E.2.2. Dense Urban – eMBB

Configuration A (carrier frequency of 4 GHz) and channel model A defined in [3] are applied for the Dense Urban – eMBB test environment.

In the evaluation, the simulation bandwidth is assumed to be 20 MHz. For 3GPP NR, the RBG size depending on the bandwidth part size (i.e. 20MHz in the evaluation) can be 4 or 8 PRBs [6]. For TSDSI, the configuration of RBG size is decoupled by bandwidth part size. In the evaluation, the RBG size is set to 16 PRBs. The downlink evaluation results for different RBG size are provided in Table 4. The overhead of control channel for large RBG size is lower than that of small RBG size. However, the performance of average and 5%-tile spectral efficiency is degraded due to the decline of frequency-selective gain.

TABLE 4

Downlink spectral efficiency for TSDSI in Dense Urban – eMBB

Scheme and antenna configuration	**Sub-carrier spacing (kHz)**	**Frame structure**	**RBG size**	**RIT**	**ITU Requirement**		**20 MHz bandwidth**
32x4 adaptive SU/MU -MIMO	30 kHz	DDDSU	4	3GPP NR	Average [bit/s/Hz/TRxP]	7.8	12.66
					5th-tile [bit/s/Hz]	0.225	0.37
32x4 adaptive SU/MU -MIMO	30 kHz	DDDSU	8	3GPP NR	Average [bit/s/Hz/TRxP]	7.8	11.9
					5th-tile [bit/s/Hz]	0.225	0.35
32x4 adaptive SU/MU -MIMO	30 kHz	DDDSU	16	TSDSI	Average [bit/s/Hz/TRxP]	7.8	11.15
					5th-tile [bit/s/Hz]	0.225	0.34

It is observed that the downlink average and 5%-tile spectral efficiency is declined when the RBG size configuration for TSDSI is used.

Similar to downlink evaluation, the uplink evaluation results for different RBG size are provided in Table 5.

TABLE 5

Uplink spectral efficiency for TSDSI in Dense Urban – eMBB

Scheme and antenna configuration	Sub-carrier spacing (kHz)	Frame structure	RBG size	RIT	ITU Requirement		20 MHz bandwidth
2x32 SU-MIMO	30 kHz	DDDSU	4	3GPP NR	Average [bit/s/Hz/TRxP]	5.4	6.94
					5th-tile [bit/s/Hz]	0.15	0.34
2x32 SU-MIMO	30 kHz	DDDSU	8	3GPP NR	Average [bit/s/Hz/TRxP]	5.4	6.53
					5th-tile [bit/s/Hz]	0.15	0.33
2x32 SU-MIMO	30 kHz	DDDSU	16	TSDSI	Average [bit/s/Hz/TRxP]	5.4	5.98
					5th-tile [bit/s/Hz]	0.15	0.29

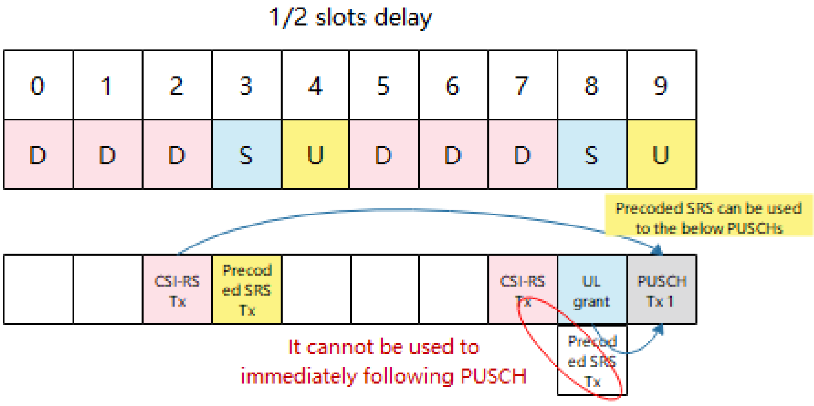
It is observed that the uplink average and 5%-tile spectral efficiency is declined when the RBG size configuration for TSDSI is used.

For precoded SRS transmission, the delay between CSI-RS measurement and precoded SRS transmission is defined as 42 OFDM symbols for 3GPP NR. For TSDSI, shorter processing delay between CSI-RS measurement and precoded SRS transmission is supported for uplink non-codebook transmission in TDD mode. The performance enhancement comes from the accurate precoder applied for PUSCH transmission. However, the delay between CSI-RS measurement and PUSCH transmission not only depends on the transmission time of precoded SRS but also depends on the transmission time of PUSCH. In the following, the impacts of delay on CSI-RS measurement, precoded SRS transmission, and PUSCH transmission are analyzed in Figure 1.

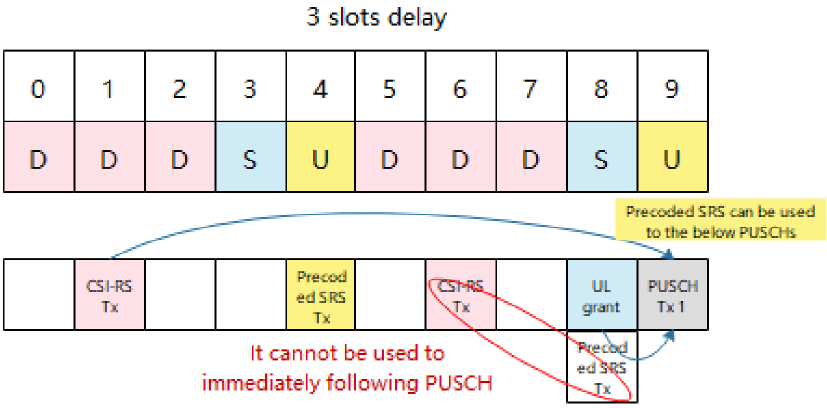
In Figure 1, the frame structure 'DDDSU' is applied for the analysis and the scheduling delay is assumed to be one slot (including 14 OFDM symbols for one slot). In Figure 1-(a), the CSI-RS is transmitted in slot 2 and the precoded SRS can be transmitted in slot 3 or slot 4. One or 2 slots delay exist between CSI-RS measurement and precoded SRS transmission. Due to the scheduling delay and uplink grant transmission, the following PUSCH cannot use the channel state information derived from the precoded SRS in slot 3. As a result, the PUSCH transmission in slot 9 would use the precoder measured in slot 2. 3 slots delay between CSI-RS measurement and precoded SRS transmission is assumed in Figure 1-(b). The PUSCH transmission in slot 9 would use the precoder measured in slot 1. It can be observed that the total delay between CSI-RS measurement and the corresponding PUSCH transmission is much larger than that of SRS precoding delay. The performance is limited by the total delay rather than the SRS precoding delay.

FIGURE 1

Delay analysis for CSI-RS measurement, precoded SRS and PUSCH transmission.



(a) 1 or 2 slots delay between CSI-RS measurement and precoded SRS transmission



(b) 3 slots delay between CSI-RS measurement and precoded SRS transmission

The evaluation results are provided in Table 6. It can be observed that there is little impact on spectral efficiency for the delay reduction of precoded SRS. Although the delay between CSI-RS measurement and precoded SRS transmission is reduced, the delay between CSI-RS measurement and PUSCH transmission is also very large. The delay analysis can be found in Figure 1. Additionally, only the wideband precoder for SRS is supported by 3GPP NR and TSDSI. The channel for wideband changes slowly so that the performance is not sensitive to delay reduction.

TABLE 6

UL spectral efficiency for fast SRS precoding (TSDSI) in Dense Urban – eMBB

Scheme and antenna configuration	Sub-carrier spacing (kHz)	Frame structure	Delay for SRS precoding	RIT	ITU Requirement		20MHz bandwidth
2x8 SU-MIMO	30	DDDSU	1 or 2 slots	TSDSI	Average [bit/s/Hz/TRxP]	5.4	7.038
					5^{th}-tile [bit/s/Hz]	0.15	0.42
2x8 SU-MIMO	30	DDDSU	3 slots	3GPP NR	Average [bit/s/Hz/TRxP]	5.4	7.036

					5th-tile [bit/s/Hz]	0.15	0.418

Based on the above analysis and the evaluation results, it is observed that there is little impact on spectral efficiency improvement for the delay reduction of precoded SRS.

II-E.2.3 Rural – eMBB

For TSDSI, pi/2 BPSK with spectrum shaping filter through non-transparent approach is introduced to improve the coverage in Rural scenario, especially for the coverage of long distance. In [4], the inter-site distance (ISD) is set to 12 km for pi/2 BPSK evaluation. But the largest inter-site distance is 6 km defined in Rural – eMBB test environment [3]. To identify the performance gain of pi/2 BPSK, the Rural configuration C – eMBB test environment with 6 km is evaluated. For the coverage of long distance, the configuration C with changed inter-site distance and carrier frequency (CF) is applied for the evaluation.

In the evaluation, the maximal transmit power for UE can achieve 26 dBm if pi/2 BPSK is enabled. Otherwise, the maximal transmit power is up to 23 dBm.

The uplink evaluation results for evaluation configuration C are provided in Table 7. For ISD = 6 km, the 5%-tile spectral efficiency can meet the requirements with and without pi/2 BPSK. The performance gain for pi/2 BPSK is very small. When the coverage is not limited, the probability to select pi/2 BPSK is very slow since the SINR is higher than the threshold of selecting pi/2 BPSK.

TABLE 7

UL spectral efficiency for pi/2 BPSK (TSDSI) in Rural - eMBB
(Evaluation configuration C with ISD = 6 km and CF = 700 MHz)

Scheme and antenna configuration	Sub-carrier spacing (kHz)	Frame structure	UE transmit power	ITU Requirement		10 MHz bandwidth
2x8 SU-MIMO	15	FDD	23 dBm without pi/2 BPSK	Average [bit/s/Hz/TRxP]	1.6	4.15
				5th-tile [bit/s/Hz]	0.045	0.093
2x8 SU-MIMO	15	FDD	26 dBm with pi/2 BPSK	Average [bit/s/Hz/TRxP]	1.6	4.04
				5th-tile [bit/s/Hz]	0.045	0.10

For the coverage of long distance, the configuration C with changed inter-site distance and carrier frequency is evaluated, i.e. ISD = 12 km and CF = 4 GHz. The evaluation results are provided in Table 8. It is observed that the 5%-tile spectral efficiency with and without pi/2 BPSK is zero. There is no coverage enhancement for pi/2 BPSK. In addition, the cumulative distribution function (CDF) of throughput is illustrated in Figure 2. It is observed that there is a large gap to coverage the cell-edge users due to the high path loss.

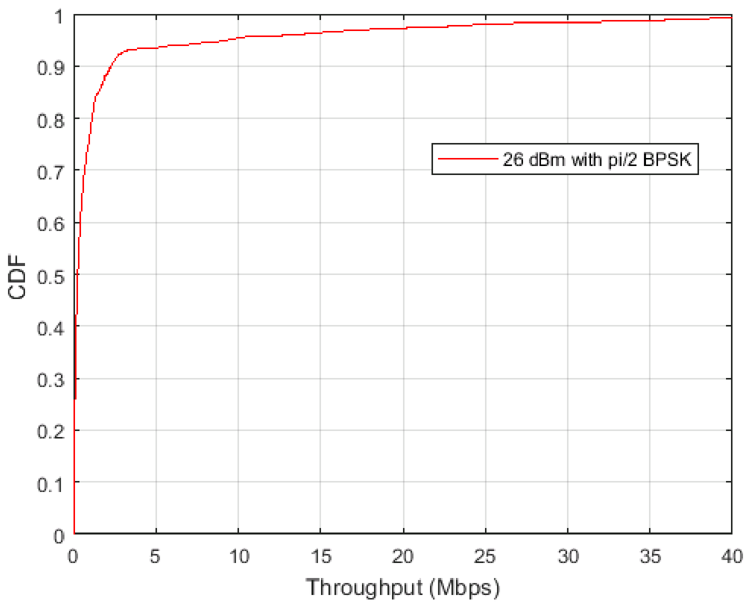
TABLE 8

**UL spectral efficiency for pi/2 BPSK (TSDSI) in Rural - eMBB
(Changed evaluation configuration C with ISD = 12 km and CF = 4 GHz)**

Scheme and antenna configuration	Sub-carrier spacing (kHz)	Frame structure	UE transmit power	ITU Requirement		Channel model A
						BW=20MHz
2x8 SU-MIMO	30	DDDSU	23 dBm without pi/2 BPSK	Average [bit/s/Hz/TRxP]	1.6	1.77
				5th-tile [bit/s/Hz]	0.045	0.0
2x8 SU-MIMO	30	DDDSU	26 dBm with pi/2 BPSK	Average [bit/s/Hz/TRxP]	1.6	1.80
				5th-tile [bit/s/Hz]	0.045	0.0

FIGURE 2

CDF of throughput for pi/2 BPSK



II-F Questions and feedback to WP 5D and/or the proponents or other IEGs

Currently, there is no further question.

Part III

Conclusion

III-1 Completeness of submission

5G Infrastructure Association finds that the submission in [4] is ‘complete’ according to [2]. 5G Infrastructure Association completed evaluations on the submissions in document IMT-2020/19 (i.e. “TSDSI technology”) and provides assessment and evaluation results. The following is identified that there is a comparison between TSDSI RIT and 3GPP NR as.

5th percentile user Spectral Efficiency:

– Configuration A is evaluated. The performance of TSDSI is lower than that of 3GPP.

– Configuration C with changed inter-site distance and carrier frequency is evaluated. TSDSI cannot improve the coverage compare to 3GPP.

Average Spectral Efficiency:

– Configuration A is evaluated. The performance of TSDSI is lower than that of 3GPP.

– Configuration C with changed inter-site distance and carrier frequency is evaluated. The performance for TSDSI and 3GPP is similar.

III-2 Compliance with requirements

These are the main conclusions on the 5G Infrastructure Association evaluation of the evaluated proposal. In Table 9 below, it is shown whether or not 5G Infrastructure Association has confirmed the proponent’s claims relating to IMT-2020 requirements.

The phrase ‘Requirements fulfilled’ in the Tables below indicates that 5G Infrastructure Association Evaluation Group assessment confirms the associated claim from the proponent that the requirement is fulfilled.

In Section III-2.1 the detailed compliance templates are summarized.

III-2.1 Overall compliance

TABLE 9

5G Infrastructure Association assessment of compliance with requirements

Characteristic for evaluation	RIT TSDSI: 5G IA assessment	Section
Peak data rate	Not provided	
Peak spectral efficiency	Not provided	
User experienced data rate	Not provided	
5th percentile user spectral efficiency	Requirements fulfilled	Part II-E.2.
Average spectral efficiency	Requirements fulfilled	Part II-E.2.
Area traffic capacity	Not provided	
User plane latency	Not provided	
Control plane latency	Not provided	

Connection density	Not provided	
Energy efficiency	Not provided	
Reliability	Not provided	
Mobility	Not provided	
Mobility interruption time	Not provided	
Bandwidth	Not provided	
Support of wide range of services	Not provided	
Supported spectrum band(s)/range(s)	Not provided	

It should be noted that the analysis behind the analytical and inspection results is not limited by properties of the test environment; hence all these conclusions are valid for all test environments.

III-2.2 Detailed compliance templates

III-2.2.1 Compliance template for services[3]

	Service capability requirements	Evaluator's comments
5.2.4.1.1	**Support for wide range of services** Is the proposal able to support a range of services across different usage scenarios (eMBB, URLLC, and mMTC)?: □YES / □NO Specify which usage scenarios (eMBB, URLLC, and mMTC) the candidate RIT or candidate SRIT can support.(1)	Not provided

(1) Refer to the process requirements in IMT-2020/2.

III-2.2.2 Compliance template for spectrum[3]

	Spectrum capability requirements	Evaluator's comments
5.2.4.2.1	**Frequency bands identified for IMT** Is the proposal able to utilize at least one frequency band identified for IMT in the ITU Radio Regulations? YES / □ NO Specify in which band(s) the candidate RIT or candidate SRIT can be deployed.	Not provided
5.2.4.2.2	**Higher Frequency range/band(s)** Is the proposal able to utilize the higher frequency range/band(s) above 24.25 GHz? YES / □ NO Specify in which band(s) the candidate RIT or candidate SRIT can be deployed. Details are provided in Section II-E.16. NOTE 1 – In the case of the candidate SRIT, at least one of the component RITs need to fulfil this requirement.	Not provided

3 If a proponent determines that a specific question does not apply, the proponent should indicate that this is the case and provide a rationale for why it does not apply.

III-2.2.3 Compliance template for technical performance[3]

Minimum technical performance requirements item (5.2.4.3.x), units, and Report ITU-R M.2410-0 section reference(1)	Category			Required value	TSDSI Value(2)	3GPP Value(2)	Requirement met?	Comments(3)
	Usage scenario	Test environment	Downlink or uplink					
5.2.4.3.4 5^{th} percentile user spectral efficiency (bit/s/Hz) *(4.4)*	eMBB	Dense Urban – eMBB	Downlink	0.225	0.34~0.37	0.35~0.37	Yes	Configuration A is evaluated. The performance of TSDSI is lower than that of 3GPP.
			Uplink	0.15	0.29~0.42	0.33~0.418	Yes	
	eMBB	Rural - eMBB	Uplink	0.045	0~0.10	0~0.093	Yes	Configuration C with changed inter-site distance and carrier frequency is evaluated. TSDSI cannot improve the coverage compare to 3GPP.
5.2.4.3.5 Average spectral efficiency (bit/s/Hz/ TRxP) *(4.5)*	eMBB	Dense Urban – eMBB	Downlink	7.8	11.15~12.66	11.9~12.66	Yes	Configuration A is evaluated. The performance of TSDSI is lower than that of 3GPP.
			Uplink	5.4	5.98~7.038	6.53~7.036	Yes	
	eMBB	Rural – eMBB	Uplink	1.6	1.80~4.04	1.77~4.15	Yes	Configuration C with changed inter-site distance and carrier frequency is evaluated. The performance for TSDSI and 3GPP is similar.

(1) As defined in Report ITU-R M.2410-0.

(2) According to the evaluation methodology specified in Report ITU-R M.2412-0.

(3) Proponents should report their selected evaluation methodology of the Connection density, the channel model variant used, and evaluation configuration(s) with their exact values (e.g. antenna element number, bandwidth, etc.) per test environment, and could provide other relevant information as well. For details, refer to Report ITU-R M.2412-0, in particular, § 7.1.3 for the evaluation methodologies, § 8.4 for the evaluation configurations per each test environment, and Annex 1 on the channel model variants.

(4) Refer to § 7.3.1 of Report ITU-R M.2412-0.

II-3 Number of test environments meeting all IMT-2020 requirements

Based on our independent evaluation report, new technologies of TSDSI differing from 3GPP are evaluated. TSDSI can meet the requirement of average spectral efficiency and 5% spectral efficiency in Dense Urban - eMBB and Rural - eMBB test environments. It should be noted that if these technologies are not applied, the evaluation results would be the same as that submitted by 3GPP.

ANNEX A

Detailed evaluation assumptions for average and 5%-tile spectral efficiency

The detailed evaluation assumptions for downlink and uplink are illustrated in Table A-1 and Table A-2, respectively.

TABLE A-1

Evaluation assumptions for downlink

Configuration parameters	Dense Urban (Configuration A)
Multiple access	OFDMA
Duplexing	TDD
Network synchronization	Synchronized
Carrier frequency	For configuration A: 4GHz
Modulation	Up to 256 QAM
Coding on data channel	LDPC
Subcarrier spacing	30 kHz
Simulation bandwidth	20MHz
Frame structure	DDDSU
Transmission scheme	Adaptive SU/MU-MIMO
MU dimension	Up to 12 layers
SU dimension	Up to 4 layers
Codeword (CW)-to-layer mapping	For 1~4 layers, CW1; For 5 layers or more, two CWs
CSI feedback	every 5ms
Interference measurement	SU-CQI
ACK/NACK delay	The next available UL slot
Antenna configuration at TRxP	For 32T: (M,N,P,Mg,Ng; Mp,Np) = (8,8,2,1,1;2,8) (dH, dV) = (0.5, 0.8) λ
Antenna configuration at UE	For 4R: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV) = (0.5, N/A) λ
Scheduling	PF
Receiver	MMSE-IRC
Channel estimation	Non-ideal
TRxP number per site	3
Mechanic tilt	90° in GCS
Electronic tilt	105° in LCS
Handover margin (dB)	1
Wrapping around method	Geographical distance-based wrapping
Criteria for selection for serving TRxP	RSRP based
Overhead	PDCCH: 2 complete symbols DMRS: Type II, based on MU-layer (dynamic in simulation) CSI-RS：32 ports per 5 slots CSI-RS for IM：ZP CSI-RS with 5 slots period; 4 RE/PRB/5 slots SSB：1 SSB per 20 ms TRS：2 consecutive slots per 20ms, 1 port, maximal 52 PRBs

Note: Other system configuration parameters align with Report ITU-R M.2412.

TABLE A-2

Evaluation assumptions for uplink

Configuration parameters	Dense Urban (Configuration A)	Rural (Configuration C)
Multiple access	CP-OFDM	DFT-S-OFDM
Duplexing	TDD	FDD/TDD
Network synchronization	Synchronized	Synchronized
Coding	LDPC	LDPC
Numerology	30kHz	15 kHz for FDD, 30 kHz for TDD
Simulation bandwidth	20 MHz	10 MHz for FDD; 20 MHz for TDD
TDD Frame structure	DDDSU	DDDSU
Transmission scheme	SU-MIMO	SU-MIMO
SU dimension	Up to 2 layers	Up to 2 layers
Codeword (CW)-to-layer mapping	For 1~4 layers, CW1; For 5 layers or more, two CWs	For 1~4 layers, CW1; For 5 layers or more, two CWs
Re-transmission delay	Next available slot	Next available slot
Antenna configuration at TRxP	For 32R: (M,N,P,Mg,Ng; Mp,Np)= (8,8,2,1,1; 2,8) (dH, dV)=(0.5, 0.8)λ;	8Rx, (8,4,2,1,1; 1,4)
Antenna configuration at UE	For 2T: (M,N,P,Mg,Ng; Mp,Np)= (1,1,2,1,1; 1,1);	For 2T: (M,N,P,Mg,Ng; Mp,Np)= (1,1,2,1,1; 1,1)
Scheduling	PF	PF
Receiver	MMSE-IRC	MMSE-IRC
Channel estimation	Non-ideal	Non-ideal
Power control parameter	P0=-60, alpha = 0.6	P0=-76, alpha = 0.8
TRxP number per site	3	3
Mechanic tilt	90° in GCS	90° in GCS
Electronic tilt	105° in LCS	92° in LCS
Handover margin (dB)	1	1
Wrapping around method	Geographical distance-based wrapping	Geographical distance-based wrapping
Criteria for selection for serving TRxP	RSRP based	RSRP based
Overhead	PUCCH: 2 PRB and 14 symbols DMRS: Type II, one front loaded symbol + 1 addition symbol SRS：2 symbols per 5 slots	PUCCH: 2 PRB and 14 symbols DMRS: Type II, one front loaded symbol + 1 addition symbol SRS：2 symbols per 5 slots

Note: Other system configuration parameters align with Report ITU-R M.2412.

References

[1] ITU-R: Minimum requirements related to technical performance for IMT-2020 radio interface(s). Report ITU-R M.2410-0, (11/2017).

[2] ITU-R: Requirements, evaluation criteria and submission templates for the development of IMT-2020. Report ITU-R M.2411-0, (11/2017).

[3] ITU-R: Guidelines for evaluation of radio interface technologies for IMT-2020. Report ITU-R M.2412-0, (10/2017).

[4] ITU-R WP 5D: Acknowledgement of candidate RIT submission from TSDSI under Step 3 of the IMT-2020 process. Document IMT-2020/19-(Rev.1)E, 23 December 2019.

[5] ITU-R WP 5D: Information of the evaluation for the terrestrial components of the radio interface(s) for IMT-2020. Liaison statement to registered Independent Evaluation Groups. Document 5D/TEMP/769(Rev 1), 16 July 2019.

[6] 3GPP TS 38.214: "Physical layer procedures for data".