NGMN KPIs and Deployment Scenarios for Consideration for IMT2020

by NGMN Alliance

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Key Performance Indicators

Table 1: General KPIs and their high level evaluation approach

KPI	Definition	Evaluation method	Remarks
Bandwidth	The highest aggregated total system bandwidth. It may be supported by single or multiple RF carriers.	Inspection	
Bandwidth scalability	The ability of the access technology to operate with different bandwidth allocations.	Inspection	This bandwidth may be supported by single or multiple RF carriers. Bandwidth scalability's relevance includes providing higher occupancy for the various spectrum block sizes encountered internationally, including those not multiples of 5/10/20 MHz.
Control plane latency	The time it takes for a mobile device in its most "battery efficient" state (e.g. RRC Idle) to start transmission of a large volume of Mobile Originated application layer data over the radio interface, from the time when data arrives at its radio protocol layer 2/3 SDU ingress point.	Analytical	The states for 5G are not yet defined, but this should typically be a state transition time between the idle state and a RRC-connected state that supports efficient transfer of large data volumes.
User plane latency	The time it takes to successfully deliver an application layer packet/message from the radio protocol layer 2/3 SDU ingress point to the radio protocol layer 2/3 SDU egress point via the radio interface in both uplink and downlink directions, where neither device nor Base Station reception is restricted by DRX.	[tbd]	In the general case the evaluation should include an assessment of the applicable procedural delays when no resource has been already allocated (e.g. request/grant, contention channel access). The value should be an average latency value, including the averaged HARQ delay.

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			However in special cases for providing a minimum latency (e.g. for URLLC use case), it can be assumed that resources are already allocated. Furthermore extra robustness can be assumed to reduce the HARQ probability, although the link efficiency impacts of that should then also be evaluated.
Latency for infrequent small packets	For infrequent application layer small packet/message transfer, the time it takes to successfully deliver an application layer packet/message from the radio protocol layer 2/3 SDU ingress point at the mobile device to the radio protocol layer 2/3 SDU egress point in the RAN, when the mobile device starts from its most "battery efficient" state .	[tbd]	This requirement shall be evaluated for at least when the device is operating in a scenario where extreme battery life and extreme coverage requirements also need to be simultaneously met.
Mobility interruption time	The shortest time duration supported by the system during which a user terminal cannot exchange user plane packets with any base station during transitions.	Analytical	Possibly different requirements for intra-frequency and inter-frequency mobility interruption and for different services. In case multi-connectivity is supported, there could be no mobility interruption time.
Inter-system handover interruption time	The shortest time duration supported by the system during which a user terminal cannot exchange user plane packets with any base station during transitions between 5G new radio and another radio access technology (RAT). Other RATs include at least LTE evolution. Additional other RATs, including non-3GPP RATs, are FFS.	Analytical	Possibly different requirements for handovers between new 5G RAT and different RATs.
Support for wide range of services	The ability of the access technology to meet the connectivity requirements of a range of existing and future (as yet unknown) services to be operable on a single continuous block of spectrum in an efficient manner.	Inspection	The components to inspect are for FFS.
Duplexing flexibility	The ability of the access technology to adapt its allocation of resources flexibly for uplink and downlink for both paired and	Inspection	Applicable for frequency bands in at least existing and future IMT-bands.

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	unpaired frequency bands.		This flexibility may be used for a wide range of requirements such as uplink/downlink traffic patterns, latency, load, etc.
Network energy efficiency	The capability of a radio access network (RAN) to minimize the RAN energy consumption while providing a much better area traffic capacity.	At least inspection. Quantitative evaluation is FFS	Note: Definition of better area traffic capacity is to be captured as part of the evaluation. Inspection: Introduce design principles taking into account energy consumption, e.g., 1) Low transmission power when there is no traffic (data to transmit) 2) No or limited increase of BS power with more antenna elements and 3) No or limited increase of BS power with larger bandwidth. 3GPP is encouraged to study models to help clarify how energy efficiency can be evaluated. Every effort should be made to obtain the energy gain without degrading the performance, but the technology should allow native flexibility for the operator to configure trade-off between energy efficiency versus performance where justified.
Peak data rate	The highest theoretical data rate which is the received data bits assuming error-free conditions assignable to a single mobile station, when all available radio resources for the corresponding link direction are utilised (i.e., excluding radio resources that are used for physical layer synchronisation, reference signals or pilots, guard bands and guard times).	Analytical	NGMN will not define requirements for peak data rate and peak spectral efficiency. Consistent user experience is of a higher priority for NGMN than peak data rate.
Peak spectral efficiency	The peak data rate normalized by bandwidth.	Analytical	See remark for peak data rate (above).

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Table 2: Deployment-scenario specific KPIs and their high level evaluation approach

KPI	Definition	Evaluation method	Remarks
Transmission/ Reception Point (TRP) average spectrum efficiency	The aggregate throughput of all users (the number of correctly received bits, i.e. the number of bits contained in the service data units (SDUs) delivered to Layer 3, over a certain period of time) divided by the channel bandwidth divided by the number of TRPs. The channel bandwidth for this purpose is defined as the effective bandwidth times the frequency reuse factor, where the effective bandwidth is the operating bandwidth normalized appropriately considering the uplink/downlink ratio. The TRP spectral efficiency is measured in bit/s/Hz/TRP. A 3 sector site consists of 3 TRPs.	System-level simulation (full-buffer)	Assessment for multi-layer and multi-band is FFS. How to evaluate outdoor and indoor users independently needs to be considered.
User experienced data rate	The 5%-percentile of the user throughput. User throughput (during active time) of an individual burst is defined as the size of a burst divided by the time between the arrival of the first packet of a burst and the reception of the last packet of the burst.	System-level simulation (FTP traffic)	This KPI needs to be achieved at the target area traffic capacity (non-full buffer) for each relevant deployment scenario. The definition of a burst depends on the traffic model and is FFS. In ITU-R evaluations, an analytical evaluation of user experienced data rate may be based on a translation from full buffer to non-full buffer (FFS). Note that this definition is modified from that defined in the NGMN 5G White Paper v1.0. The old definition remains a desirable long term ambition for further improved consistency, but the new definition is considered a more realistic short term definition considering simulation

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			complexity and achievability.
5th percentile user spectrum efficiency	The cell edge user spectral efficiency is defined as 5% point of the cumulative distribution function (CDF) of the normalized user throughput. The (normalized) user throughput is defined as the average user throughput (the number of correctly received bits by users, i.e., the number of bits contained in the SDU delivered to Layer 3, over a certain period of time, divided by the channel bandwidth and is measured in bit/s/Hz. The channel bandwidth for this purpose is defined as the effective bandwidth times the frequency reuse factor, where the effective bandwidth is the operating bandwidth normalised appropriately considering the uplink/downlink ratio.	System-level simulation (full buffer)	This KPI was previously called user experienced spectrum efficiency in NGMN LS to RAN#70. Assessment for multi-layer and multi-band is FFS. How to evaluate outdoor and indoor users independently needs to be considered.
Area traffic capacity	Full buffer: Total traffic throughput served per geographic area (in Mbit/s/m^2). The computation of this metric is based on full buffer traffic.	Analytical	For ITU-R, this KPI could be computed from the TRP spectral efficiency, site density and bandwidth.
	Non full buffer: Total traffic throughput served per geographic area (in Mbit/s/m^2). Both the user experienced data rate and the area traffic capacity need to be evaluated at the same time using the same traffic model.	System level simulations (FTP traffic)	This KPI is used to derive the burst arrival rate for the FTP simulations.
Connection density	Total number of devices fulfilling specific QoS per unit area (per km^2).	[tbd]	Foreseen as most relevant for mMTC. QoS definition should take into account the amount of data generated within a time t_gen that can be sent or received within a given time, t_sendrx, with x% probability. Report bandwidth used in evaluation.
Mobility	Maximum user speed at which a defined QoS can be achieved (in km/h).	Simulation (link and system level)	Mobility classes and QoS will be defined for each scenario.
Reliability	The success probability of transmitting a layer 2/3 packet of [x bytes] within a maximum time of [t ms], which is the time it takes to deliver a	Link-level simulation	Foreseen as most relevant for URLLC. If channel access is not granted, the reliability

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	small data packet from the radio protocol layer 2/3 SDU ingress point to the radio protocol layer 2/3 SDU egress point of the radio interface at a certain channel quality.		and delay of that should be taken into account. The channel quality target and its variation characteristics need to be defined, including the relevant channel model. Mobility aspects can be treated as part of the channel quality to be targeted.
Device battery life	The battery life of the device without recharge. For at least mMTC, device battery life in extreme coverage shall be based on the activity of mobile originated data transfer consisting of 200 bytes UL per day followed by 20 bytes DL from maximum coupling loss of 164 dB, assuming a stored energy capacity of 5Wh.	Link-level simulation (Reuse TR 45.820)	Battery life KPI definition of other terminal types beside mMTC is FFS.
Extreme Coverage	"Maximum coupling loss" in uplink and downlink between device and Base Station site (antenna connector(s)) for a data rate of 160bps, where the data rate is observed at the egress/ingress point of the radio protocol stack in uplink and downlink.	Link-level simulation (Reuse TR 45.820)	Foreseen as most relevant for mMTC.
UE energy efficiency	The capability of a UE to reduce UE modem energy consumption while sustaining better performance (e.g., mobile broadband data rate).	Inspection	Foreseen as most relevant for eMBB.

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Deployment scenarios – key challenges and evaluation goals

Table 3: Deployment scenarios with associated key challenges and evaluation goals

Usage scenario	Deployment scenario	Key challenges	Most relevant KPIs	Evaluation goals	Remarks
eMBB	Indoor hotspot (eMBB-InH)	- high capacity - high density - consistent user experience - poor cell isolation	- TRP spectrum efficiency - 5th percentile user spectrum efficiency - user experienced data rate	- Show that high frequency bands can be used indoor.	Candidate scenario for system level evaluations.
	Dense urban (eMBB-UMx)	- high capacity - high density - consistent user experience - poor cell isolation - users distributed in height	- TRP spectrum efficiency - 5th percentile user spectrum efficiency - user experienced data rate - [network energy efficiency]	- Clarify the feasibility of different outdoor deployment options for serving both outdoor and indoor users: macro only or macro and outdoor small cells; considering different spectrum options: low frequency bands only , high frequency bands only or a combination of both high and low frequency bands.	Candidate scenario for system-level evaluations.
	Urban macro (eMBB-UMa)	- capacity - consistent user experience	- TRP spectrum efficiency - 5th percentile user spectrum efficiency - user experienced data rate - [network energy efficiency]	- Clarify the feasibility of a macro outdoor deployment considering different spectrum options: low frequency bands only, high frequency bands only or a combination of both high and low frequency bands to serve both outdoor and indoor users.	Candidate scenario for system-level evaluations.
	Rural macro (eMBB-RMa)	- consistent user experience over wide area - capacity - high user mobility	- TRP spectrum efficiency - 5th percentile user spectrum efficiency - user experienced data rate - mobility - [network energy efficiency]	- Show that low frequency bands can provide wide area coverage. - Clarify the feasibility of meeting the user experience requirement and the capacity requirement with a reasonable site density.	Candidate scenario for system-level evaluations.
	High speed train (eMBB-HS)	- very high speed - high capacity - high connection density - consistent user experience	- user experienced data rate - mobility	- Show that link performance can be maintained at very high speeds. - Show the capacity requirement can be met with a reasonable site density.	Special test (link level) could be employed, e.g., under a rural macro setting.

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mMTC		- massive number of devices - coverage - energy constraints	- connection density - extreme coverage - device battery life	- Clarify the coverage and capacity impact of offering mMTC service (e.g., by evaluation of link-level performance).	Some relevant KPIs may be evaluated without system level simulations. For KPIs that need system level simulations, eMBB deployment scenarios could be reused, possibly with some parameter changes. The need for additional non-eMBB specific deployment scenarios is FFS.
URLLC		- high reliability - very low latency - capacity - coverage - mobility	- latency - reliability	- Clarify the coverage and capacity impact of offering URLLC service (e.g., by evaluation of link-level performance).	

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Table 4: Deployment scenarios and spectrum options

Deployment scenario	KPI	KPI value	Deployment options[1]	Spectrum options[2]	Bandwidth[3]	Comments
Indoor hotspot (eMBB-InH)			Indoor floor, ISD 20m	Above 6 GHz (around 30 GHz [4]or around 70 GHz[5])		
			100% indoors	Above 6 GHz (around 30 GHz or around 70 GHz) and Below 6 GHz (around 4 GHz)		Evaluation only required if >6GHz cannot meet requirement.
Dense urban (eMBB-UMx)			Macrocell only, ISD 200m 20% outdoor (3 km/h) and 80% indoor (3 km/h)	Below 6 GHz (around 4 GHz)		
				Above 6 GHz (around 30 GHz)		
				Below 6 GHz (around 4 GHz) and above 6 GHz (around 30 GHz) combined		
			Macro cells with outdoor small cells Macro ISD: 200m Small cell ISD: [3][6] small cell per macro sector. Users: 20% outdoor (3 km/h)	Below 6GHz (around 4 GHz) for both macro and small cells		
				Above 6 GHz (around 30 GHz) for both macro and small cells		
				Below 6 GHz (around 4 GHz) and above 6 GHz (around 30 GHz) combined for macro and small cells		

[1] Indicates deployment options that can be studied to identify the option(s) that can meet the requirements. Not all options need to be necessarily evaluated.
[2] The options noted here are for evaluation purpose, and do not mandate the deployment of these options or preclude the study of other spectrum options.
[3] This is not the simulation bandwidth. Simulation bandwidth may be much smaller. This bandwidth denotes an aspirational background to the capacity/user experienced data rate/area traffic capacity requirements and not necessarily what will be available to an operator in a single block. The bandwidth value given is per operator.
[4] A range of bands from 24 GHz – 40 GHz identified for WRC-19 are currently being considered and around 30 GHz is chosen as a proxy for this range.
[5] A range of bands from 66 GHz – 86 GHz identified for WRC-19 are currently being considered and around 70 GHz is chosen as a proxy for this range.
[6] This does not preclude the study of other options (e.g., 4 or 10 small cells).

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			and 80% indoor (3 km/h)			
				Below 6 GHz (around 4 GHz) for macro and above 6 GHz (around 30 GHz or around 70 GHz) for small cells		
Urban macro (eMBB-UMa)			Macro only, hex grid ISD: 500 m Users: 1)20% outdoor (3 km/h) and 80% indoor (3 km/h) 2)100% in cars (30 km/h)	Below 6 GHz (around 2 GHz or around 4 GHz)		
				Above 6 GHz (around 30 GHz)		
				Below 6 GHz (around 2 GHz or around 4 GHz) and above 6 GHz (around 30 GHz) combined.		
Rural macro (eMBB-RMa)			Macro only ISD: 1732 m Users: 1)20% outdoor (3 km/h) and 80% indoor (3 km/h) 2)100% in cars (120 km/h)	Below 6 GHz (around 800 MHz or around 4 GHz).		Note: Bands above 6 GHz if needed.
			Macro only ISD: 5 km Users: 1)20% outdoor (3 km/h) and 80% indoor (3 km/h) 2)100% in cars (120 km/h)	Below 6 GHz (around 800 MHz and around 2 GHz combined)		
High speed			Outdoor base stations to users	Below 6 GHz (Tbc)		

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(eMBB-HS) **Train**			in trains @ 500 Km/h Use of link level or system level simulation is TBD			
			Outdoor BS to relay on trains, and then from relay to users in trains @ 500 Km/h Use of link level or system level simulation is TBD	For BS to relay: Below 6 GHz (around 4 GHz) For relay to UE: Above 6 GHz (around 30 GHz or around 70 GHz) and below 6 GHz (around 4 G Hz)		Evaluations will focus on the BS to relay link.
				For BS to relay: Above 6 GHz (around 30 GHz) For relay to UE: Above 6 GHz (around 30 GHz or around 70 GHz) and below 6 GHz (around 4 GHz)		Evaluations will focus on the BS to relay link.

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