15 SIGNALLING PROCEDURES

15.1 LTE RRC IDLE MODE

★ System Information Blocks (SIB) belonging to LTE can be used to broadcast:

  o a 5G Status Indicator within SIB2 which allows the UE to display a 5G icon. This icon informs the end-user that 5G services are available at that location. The 5G Status Indicator is important for network configurations which provide 5G services while relying upon LTE to support RRC Idle mode. For example, LTE cells which belong to an EN-DC Non-Standalone Base Station can broadcast the 5G Status Indicator

  o cell reselection information within SIB24 which allows the UE to move from LTE to NR while in RRC Idle mode. This content is applicable to networks which support RRC Idle mode for both LTE and NR. SIB5 belonging to the NR radio access network broadcasts cell reselection information which allows the UE to move from NR to LTE while in RRC Idle mode

★ The 5G Status Indicator broadcast by SIB2 is presented in Table 324. The RRC signalling protocol uses the 'upperLayerIndication' to serve as the 5G Status Indicator. A separate instance can be broadcast for each PLMN identity associated with the LTE cell

extract from *SystemInformationBlockType2* belonging to the LTE system			
PLMN-InfoList-r15	SEQUENCE {1 to 6 instances}		
	PLMN-Info-r15	upperLayerIndication-r15	true

Table 324 – 5G Status Indicator within LTE SIB2

★ Use of the 5G Status Indicator is dependent upon the UE implementation. UE are expected to evaluate the 5G Status Indicator in combination with other information prior to displaying the 5G icon to the end-user. A 5G capable device is not expected to display the 5G icon if the end-user has not subscribed to 5G services. The 4G NAS: *Attach Accept* message can include the 'EPS Network Feature Support' parameter set presented in Figure 445. This parameter set includes the 'RestrictDCNR' flag which indicates whether or not the end-user is authorised to use Dual Connectivity with NR. The UE can use this flag in combination with the 5G Status Indicator to determine whether or not the 5G icon should be displayed

8 bits						
CP CIoT	ERw/o PDN	ESR PS	CS-LCS	EPC-LCS	EMC BS	IMS VoPS
15 bearers	IWKN26	Restrict DCNR	Restrict EC / ePCO	HC-CP CIoT	S1-U data	UP CIoT

Figure 445 – EPS Network Feature Support information element from NAS: Attach Accept

★ Use of the 5G Status Indicator is complicated by potential differences in the LTE and NR coverage areas. Figure 446 illustrates a scenario which is based upon LTE coverage provided by a low operating band and NR coverage provided by a high operating band. In this case, LTE coverage extends further than NR coverage due to the difference in propagation loss. This allows a UE to receive the 5G Status Indicator from LTE at locations where 5G services are not available. In this case, it can be misleading to display the 5G icon to the end-user
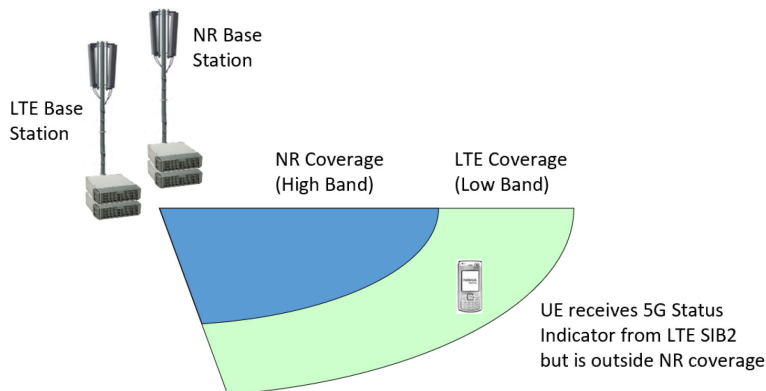

Figure 446 – Reception of 5G Status Indicator while outside NR coverage

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★ Ideally, the UE should complete inter-system measurements to verify that NR coverage exists prior to displaying the 5G icon. However, these inter-system measurements are not simplistic because the UE may not have knowledge of the NR carrier to be measured. When using the EN-DC Non-Standalone Base Station architecture, the LTE system does not specify NR carrier information within SIB24 because cell reselection towards NR is not supported. The UE could complete a band scan to identify candidate NR carriers but the NR Base Station is not required to broadcast SIB1 so the UE may not be able to determine which NR carriers belong to the registered network. In addition, if measurements are completed to verify 5G coverage then the UE is likely to require an SS-RSRP threshold to determine whether or not the NR signal strength is adequate. If the LTE Base Station uses measurement based Secondary Cell addition, then the SS-RSRP threshold used by the Base Station should ideally be aligned with the threshold used by the UE

★ The GSM Association (GSMA) has agreed upon a set of 4 candidate UE configurations which determine when a UE should display the 5G icon. These 4 configurations are presented in Table 325. None of the configurations allow the UE to display the 5G icon when using an LTE cell which does not belong to a Non-Standalone (NSA) Base Station. All of the configurations allow the UE to display the 5G icon when using an NG-RAN connected to the 5G Core Network (5GC)

★ Otherwise, configuration 'A' is the most conservative because it limits the UE to displaying the 5G icon when the UE is already connected to both LTE and NR cells. In contrast, Configuration 'D' is the most aggressive because it allows the UE to display the 5G icon when using only an LTE cell belonging to an NSA Base Station, without having to verify NR coverage. Configurations 'B' and 'C' rely upon the UE verifying that NR coverage exists

★ The national regulator may specify the configuration to be used. Otherwise, an operator may specify the preferred configuration to each UE vendor

		Config A	Config B	Config C	Config D
1	UE is Idle under LTE cell not supporting NSA, or UE is Connected to LTE cell not supporting NSA	4G	4G	4G	4G
2	UE is Idle under LTE cell supporting NSA, without detection of NR coverage, or UE is Connected to LTE cell supporting NSA, without detection of NR coverage	4G	4G	4G	5G
3	UE is Connected to LTE only, while connected to an LTE cell supporting NSA, with detection of NR coverage	4G	4G	5G	5G
4	UE is Idle under LTE cell supporting NSA, with detection of NR coverage	4G	5G	5G	5G
5	UE is connected to both LTE and NR under an LTE cell supporting NSA	5G	5G	5G	5G
6	UE is Idle under NG-RAN while attached to 5GC, or UE is Connected to NG-RAN while attached to 5GC	5G	5G	5G	5G

Table 325 – UE configurations for displaying the 5G icon

★ The content of the LTE SIB24 is presented in Table 326. This SIB is broadcast when cell reselection from LTE to NR is supported. It is not applicable to the EN-DC Non Standalone Base Station because in this case, NR does not support an RRC Idle mode

★ LTE SIB24 allows up to 8 NR carriers to be specified using their ARFCN. These ARFCN correspond to the center frequency of the SS/PBCH Blocks rather than the center frequency of the channel bandwidth. Multiple operating bands can be linked to each of the specified ARFCN, i.e. in the case that operating bands overlap

★ *measTimingConfig* provides the periodicity and time offset to be used when measuring the SS/PBCH Blocks belonging to the target NR carrier. It also provides a measurement duration which should be sufficiently long to capture all of the SS/PBCH Blocks available to measure

★ *subcarrierSpacingSSB* specifies the subcarrier spacing of the SS/PBCH Blocks belonging to the target NR carrier so can be configured with values of 15 or 30 kHz for Frequency Range 1, and 120 or 240 kHz for Frequency Range 2

★ *ss-RSSI-Measurement* specifies the slots and symbols which can be used for RSSI measurements when evaluating RSRQ.

★ *measurementSlots* defines a bit string where each bit corresponds to a slot within the measurement duration. For example, if *ssb-Duration* is set to 5 subframes and the subcarrier spacing is 15 kHz then the bit string will have a length of 5 bits because there are 5 slots in 5 subframes. In contrast, if *ssb-Duration* is set to 5 subframes and the subcarrier spacing is 240 kHz then the bit string will have a length of 80 bits because there are 80 slots in 5 subframes. The UE measures the RSSI during slots which correspond to a '1' within the bit string

★ *endSymbol* defines the symbols within the *measurementSlots* which can be used to measure the RSSI. The value of *endSymbol* is a pointer to a row within a 3GPP standardised look-up table (Table 241 in section 10.2). For example, *endSymbol* = '0' means that the UE can complete RSSI measurements during symbols 0 and 1, while *endSymbol* = '2' means that the UE can complete RSSI measurements during symbols 0, 1, 2, 3, 4 and 5

★ *cellReselectionPriority* and *cellReselectionSubPriority* define the Absolute Priority of the target NR carrier. These values allow the UE to categorise each NR carrier as either higher priority or lower priority than the current LTE carrier. The appropriate cell reselection procedure and parameter set can then be applied towards each NR carrier

★ *threshX-High* and *threshX-HighQ* are applicable when completing cell reselection towards a higher priority NR carrier. These parameters define minimum SS-RSRP and SS-RSRQ thresholds respectively. *threshX-High* defines a threshold relative to *q-RxLevMin*,

whereas *threshX-HighQ* defines a threshold relative to *q-QualMin*. For example, if *q-RxLevMin* is set to -60 (which maps to a value of -120 dBm) and *threshX-High* is set to 5 (which maps to a value of 10 dB), then the target NR cell must have an SS-RSRP > -110 dBm to allow cell reselection

★ *threshX-Low* and *threshX-LowQ* are applicable when completing cell reselection towards a lower priority NR carrier. These parameters define minimum SS-RSRP and SS-RSRQ thresholds respectively. *threshX-Low* defines a threshold relative to *q-RxLevMin*, whereas *threshX-LowQ* defines a threshold relative to *q-QualMin*

LTE *SIB24*						
carrierFreqListNR-r15	SEQUENCE {1 to 8 instances}					
	carrierFreq-r15	0 to 3279165				
	multiBandInfoList-r15	SEQUENCE {1 to 32 instances}				
		FreqBandIndicatorNR-r15	1 to 1024			
	multiBandInfoListSUL-r15	SEQUENCE {1 to 32 instances}				
		FreqBandIndicatorNR-r15	1 to 1024			
	measTimingConfig-r15	periodicityAndOffset-r15	CHOICE			
			sf5-r15	0 to 4	sf40-r15	0 to 39
			sf10-r15	0 to 9	sf80-r15	0 to 79
			sf20-r15	0 to 19	sf160-r15	0 to 159
		ssb-Duration-r15	1, 2, 3, 4, 5 subframes			
	subcarrierSpacingSSB-r15	15, 30, 120, 240 kHz				
	ss-RSSI-Measurement-r15	measurementSlots-r15	BIT STRING {1 to 80 bits}			
		endSymbol-r15	0 to 3			
	cellReselectionPriority	0 to 7				
	cellReselectionSubPriority	0.2, 0.4, 0.6, 0.8				
	threshX-High-r15	0 to 31 (actual value = signalled value × 2)				
	threshX-Low-r15	0 to 31 (actual value = signalled value × 2)				
	threshX-Q-r15	threshX-HighQ-r15	0 to 31			
		threshX-LowQ-r15	0 to 31			
	q-RxLevMin-r15	-70 to -22 (actual value (dBm) = signalled value × 2)				
	q-RxLevMinSUL-r15	-70 to -22 (actual value (dBm) = signalled value × 2)				
	p-MaxNR-r15	-30 to 33 dBm				
	ns-PmaxListNR-r15	SEQUENCE {1 to 8 instances}				
		additionalPmaxNR-r15		-30 to 33 dBm		
		additionalSpectrumEmissionNR-r15		0 to 7		
	q-QualMin-r15	-43 to -12 dB				
	deriveSSB-IndexFromCell-r15	BOOLEAN				
	maxRS-IndexCellQual-r15	1 to 16				
	threshRS-Index-r15	nr-RSRP-r15	0 to 127			
		nr-RSRQ-r15	0 to 127			
		nr-SINR-r15	0 to 127			
	multiBandNsPmaxListNR-v1550	SEQUENCE {1 to 31 instances} of *NS-PmaxListNR-r15*				
	multiBandNsPmaxListNR-SUL-v1550	SEQUENCE {1 to 32 instances} of *NS-PmaxListNR-r15*				
	ssb-ToMeasure-r15	CHOICE				
		shortBitmap-r15	BIT STRING {4 bits}			
		mediumBitmap-r15	BIT STRING {8 bits}			
		longBitmap-r15	BIT STRING {64 bits}			
t-ReselectionNR-r15	0 to 7 seconds					
t-ReselectionNR-SF-r15	sf-Medium	0.25, 0.5, 0.75, 1.0				
	sf-High	0.25, 0.5, 0.75, 1.0				

Table 326 – Content of the LTE System Information Block 24 (SIB24)

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★ *q-RxLevMin* and *q-QualMin* define the minimum SS-RSRP and SS-RSRQ requirements for the target NR carrier. The RSRQ requirement is optional so may be excluded from SIB24

★ *q-RxLevMinSUL* defines a minimum SS-RSRP requirement which is applicable if SIB24 specifies a Supplemental Uplink band and if the UE supports the corresponding Supplemental Uplink band combination. The link budget belonging to a Supplemental Uplink may differ from the link budget for the Normal Uplink. If coverage is uplink limited then *q-RxLevMinSUL* can be adjusted relative to *q-RxLevMin* to reflect the difference in link budgets

★ *p-MaxNR* defines the maximum UE transmit power permitted when using a cell belonging to the target NR carrier

★ *ns-PmaxListNR* provides a list of up to 8 pairs of {*additionalPmaxNR*, *additionalSpectrumEmissionNR*}. These pairs specify additional spectrum emission requirements which should be satisfied if the UE uses the corresponding maximum transmit power. The values are applicable to the first operating band listed within *multiBandInfoList*

★ *deriveSSB-IndexFromCell* indicates whether or not the UE can assume radio frame alignment for all cells belonging to the target NR carrier. Radio frame alignment allows the UE to use the timing belonging to one NR cell to derive the SSB Indices belonging to other NR cells. This helps to reduce measurement delays because it avoids the requirement to decode the PBCH belonging to each individual NR cell

★ *maxRS-IndexCellQual* and *threshRS-Index* are used when deriving a 'cell level' result from a set of 'beam level' measurements. If the target NR cell is configured with multiple SS/PBCH beams then it is necessary to derive a 'cell level' result from one or more 'beam level' measurements. If *maxRS-IndexCellQual* is excluded, the UE sets the 'cell level' result equal to the highest 'beam level' measurement. Otherwise, the UE derives the 'cell level' result by calculating a linear average of the highest 'beam level' measurements which exceed *threshRS-Index*. The maximum number of 'beam level' measurements included in the average is defined by *maxRS-IndexCellQual*. If none of the beam level measurements exceed *threshRS-Index*, the 'cell level' result is set equal to the highest 'beam level' measurement

★ *multiBandNsPmaxListNR* provides a list of up to 8 pairs of {*additionalPmaxNR*, *additionalSpectrumEmissionNR*} for each operating band listed within *multiBandInfoList* (with the exception of the first band which is already catered for using *ns-PmaxListNR*). Each list specifies additional spectrum emission requirements which should be satisfied if the UE uses the corresponding maximum transmit power after selecting the corresponding operating band. Similarly, *multiBandNsPmaxListNR-SUL* provides a list of up to 8 pairs of {*additionalPmaxNR*, *additionalSpectrumEmissionNR*} for each operating band listed within *multiBandInfoListSUL*

★ *ssb-ToMeasure* specifies the set of SS/PBCH Blocks to be measured within the measurement duration. A short, medium or long bitmap is broadcast according to the frequency range. A short bitmap is broadcast for carriers below 3 GHz (up to 4 SS/PBCH), a medium bitmap is broadcast for carriers between 3 GHz and 6 GHz (up to 8 SS/PBCH), and a long bitmap is broadcast for carriers greater than 6 GHz (up to 64 SS/PBCH). The UE measures SS/PBCH Blocks which correspond to a '1' within the bit string. The UE measures all SS/PBCH Blocks if *ssb-ToMeasure* is excluded from the SIB

★ *t-ReselectionNR* defines the time-to-trigger for cell reselection towards NR. *sf-Medium* and *sf-High* define scaling factors for medium and high mobility conditions. *t-ReselectionNR* is multiplied by the appropriate scaling factor when medium or high mobility is detected

★ In the case of the EN-DC Non-Standalone Base Station, NR Secondary Cell Addition may be supported from only a subset of LTE carriers. This may result from band combinations which have not been standardised within the 3GPP specifications. It then becomes necessary to move 5G subscribers onto an LTE carrier which supports NR Secondary Cell Addition. This scenario is illustrated in Figure 447

★ 5G subscribers can be moved onto the appropriate LTE carrier using RRC Idle mode procedures but it is necessary to ensure that the solution is transparent to non-5G subscribers. The LTE Base Station can receive subscription information within the S1AP: *Initial Context Setup Request*. This message can include an 'NR Restriction in EPS as Secondary RAT' flag and also a Subscriber Profile Identity (SPID). The EPC can allocate specific SPID values to 5G subscribers allowing the Base Station to differentiate those subscribers. In addition, the S1AP: *Initial Context Setup Request* includes UE capability information so the Base Station can verify that the subscriber is using a 5G capable device
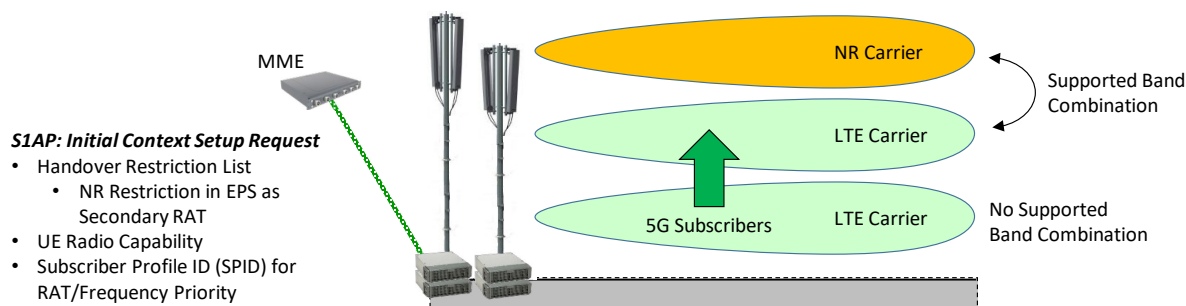

Figure 447 – NR Secondary Cell Addition supported from a subset of LTE carriers

★ The LTE Base Station can allocate UE specific Absolute Priorities to the 5G subscribers within the *RRC Release* message. These Absolute Priorities can be configured to ensure that UE move onto an LTE carrier which supports 5G Secondary Cell Addition

★ 3GPP References: TS 36.331, TS 36.413, TS 24.301