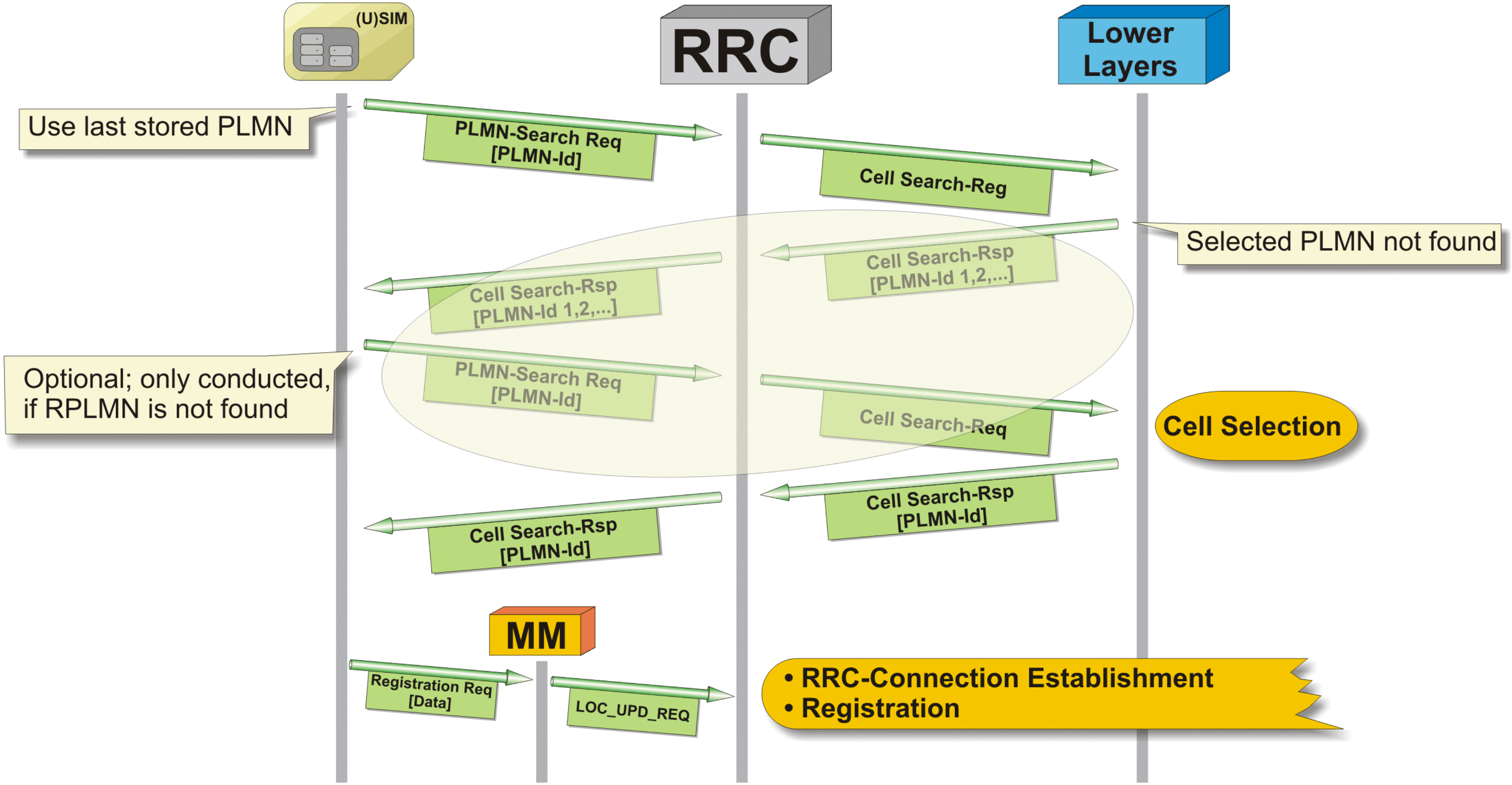
NAS Aspects of the PLMN and Cell Selection Procedure



NAS Aspects of the PLMN and Cell Selection Procedure

The figure summarizes the PLMN and cell selection process, if the automatic network selection mode is chosen.

⇒ The SIM/USIM initiates the PLMN-search of the access stratum. The SIM/USIM prioritizes the very PLMN to which the UE was registered prior to the last power-off (⇔ referred to as RPLMN (Registered PLMN)).

⇒ The AS (Access Stratum) performs a cell search procedure and reads the system information of the locally available cells

It is implementation depending, whether or not the MT prioritizes the cell search on a previously stored list of cells (e.g. from previously received neighbor cell information).

⇒ If no suitable cell of the RPLMN can be identified, the AS reports back to the SIM/USIM the list of PLMN's which are currently available.

⇒ Out of this list, the SIM/USIM selects the very PLMN with the highest priority and requests the AS to perform a second PLMN-search procedure.

⇒ The AS performs this second PLMN-search procedure and selects the *strongest* cell of that PLMN *and* RAT.

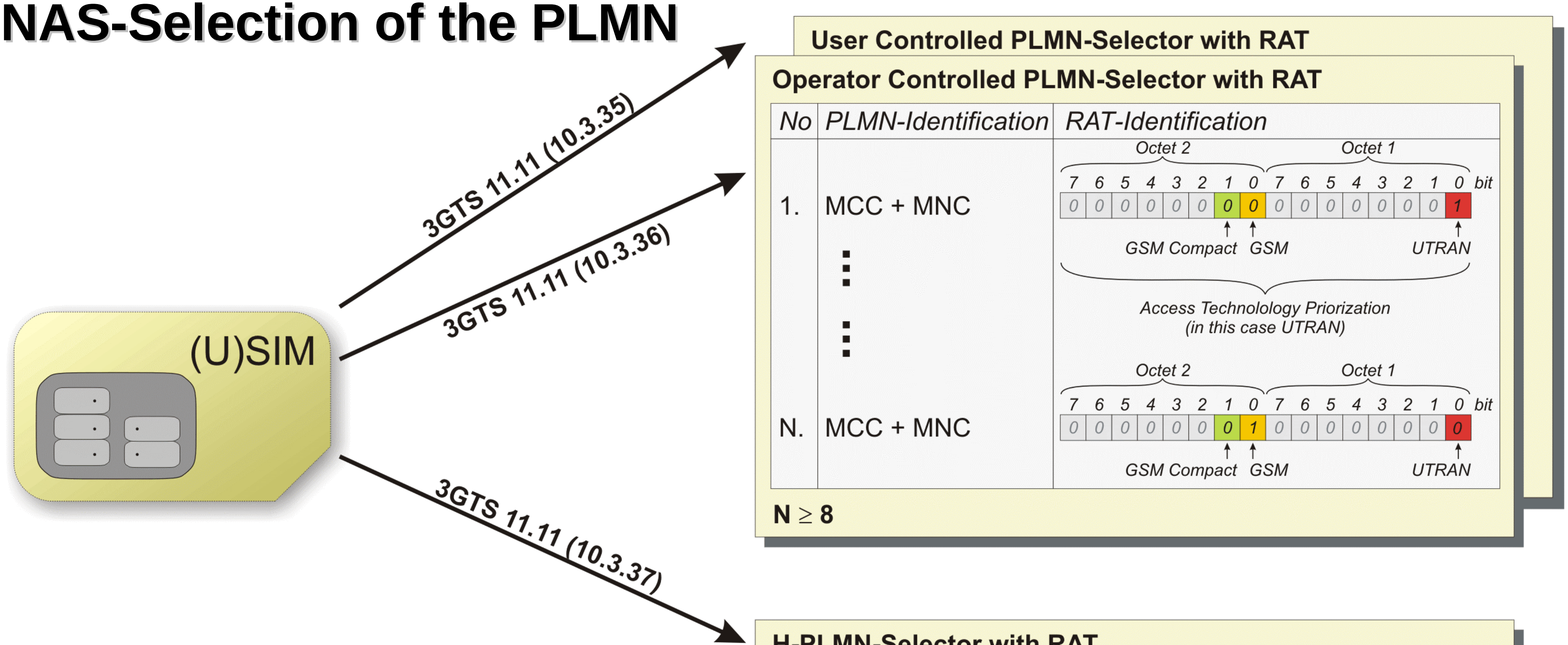
⇒ The successful outcome of the cell selection process is reported back to the SIM/USIM.

⇒ Consequently, the SIM/USIM requests the MM-layer (or possibly the GMM-layer) to perform a registration procedure.

⇒ The MM-layer sends an MM: LOC_UPD_REQ-messages to the RRC-layer which in turn triggers the establishment of an RRC-connection and the registration procedure.

[3GTS 25.304 (10)]

NAS-Selection of the PLMN



H-PLMN-Selector with RAT

	No	PLMN-Identification	RAT-Identification
mandatory	*1.*	*MCC + MNC (H-PLMN)*	*e.g. UTRAN*
	2.	*MCC + MNC (H-PLMN)*	*e.g. GSM*
optional		⋮	⋮
	N.	*MCC + MNC (H-PLMN)*	*e.g. GSM*

NAS-Selection of the PLMN

Older SIM-cards which are compliant to Rel. 98 specification (3GTS 11.11), do only support the prioritization of different PLMN's (⇔ 3GTS 11.11 (10.3.4)). Starting with Rel. 99, SIM-cards deploy *in addition* to this list three more lists:

User Controlled PLMN Selector with Access Technology (⇔ 3GTS 11.11 (10.3.35))

This list is user controlled and allows the prioritization of different V-PLMN's and their access technology. The user may for instance prioritize that when roaming into country X, V-PLMN A with RAT 1 shall be highest priority while the same V-PLMN A with RAT 2 shall be second priority.
It shall be possible to populate at least eight different PLMN's.

The bit which identifies the UTRAN-RAT does not distinguish between UTRA-FDD and UTRA-TDD. Through the inclusion of the RAT, the user is for instance able to restrict his/her roaming access in a foreign country to the less sophisticated but cheaper GSM of a friendly network operator vs. roaming to the more sophisticated but potentially very expensive UTRAN of another network operator.

Operator Controlled PLMN Selector with Access Technology (⇔ 3GTS 11.11 (10.3.36))

This list is operator controlled and allows the prioritization of different V-PLMN's and their access technology. It shall be possible to populate at least eight different PLMN's. The operator may adjust this list during operation through e.g. binary short messages or other means.

Note that the "user controlled PLMN-selection list" in 3GTS 11.11 (10.3.35) takes precedence over the "operator controlled PLMN-selection list" in 3GTS 11.11 (10.3.36).

H-PLMN Selection with Access Technology (⇔ 3GTS 11.11 (10.3.37))

This list allows to prioritize the different access technologies (GSM, UTRAN) of the H-PLMN network operator. It shall be possible to distinguish at least two different RAT's of a network operator. That is, the population of at least two entries is mandatory.

The Cell Ranking Criterion for Neighbor Cells with HCS

w = 0 ⇔ [PENALTY_TIME(neigh,n) - T(n)] < 0

w = 1 ⇔ [PENALTY_TIME(neigh,n) - T(n)] ≥ 0

(1 - L(neigh,n)) = 1 ⇔ HCS_PRIO(s) = HCS_PRIO(neigh,n)

(1 - L(neigh,n)) = 0 ⇔ HCS_PRIO(s) ≠ HCS_PRIO(neigh,n)

measured value of P-CPICH-RSCP of Neighbor Cell → Q-Rxlevmeas(neigh,n)

from SIB 11 of Serving Cell → Q-Offset-1-S-N(neigh,n)

from SIB 11 of Serving Cell → TEMP_OFFSET1(neigh,n)

R(neigh,n) = Q-Rxlevmeas(neigh,n) - Q-Offset-1-S-N(neigh,n) - [TEMP_OFFSET1(neigh,n) * w * (1 - L(neigh,n)))]

⇐ *If CellSelectQualityMeasure = P-CPICH-RSCP*
(one ranking)

R(neigh,n) = Q-Rxlevmeas(neigh,n) - Q-Offset-1-S-N(neigh,n) - [TEMP_OFFSET1(neigh,n) * w * (1 - L(neigh,n))]

⇐ *If CellSelectQualityMeasure = P-CPICH-Ec/No*
1.Ranking

R(neigh,n) = Q-Qualmeas(neigh,n) - Q-Offset-2-S-N(neigh,n) - [TEMP_OFFSET2(neigh,n) * w * (1 - L(neigh,n))]

2.Ranking

measured value of P-CPICH-Ec/No of Neighbor Cell → Q-Qualmeas(neigh,n)

from SIB 11 of Serving Cell → Q-Offset-2-S-N(neigh,n)

from SIB 11 of Serving Cell → TEMP_OFFSET2(neigh,n)
CPICH-RSCP ⇒ use TEMP_OFFSET1
CPICH-Ec/No ⇒ use TEMP_OFFSET2

The Cell Ranking Criterion for Neighbor Cells with HCS

In contrast to the cell ranking criterion without HCS, the one illustrated on the graphics page is extended by the neighbor cell specific temporary offset. The temporary offset is used to further decrease the chances that a neighbor cell can be the serving cell.

<u>However, this is only true if:</u>

- **W = 1**
  This condition is only true during the neighbor cell specific penalty time. However, the respective timer Tn (which needs to exceed the penalty time) is only started for a neighbor cell with a different HCS-priority than the neighbor cell, if:
  ⇒ Q-Rxlevmeas (neigh, n) or Q-Qualmeas (neigh, n) > Q-HCS

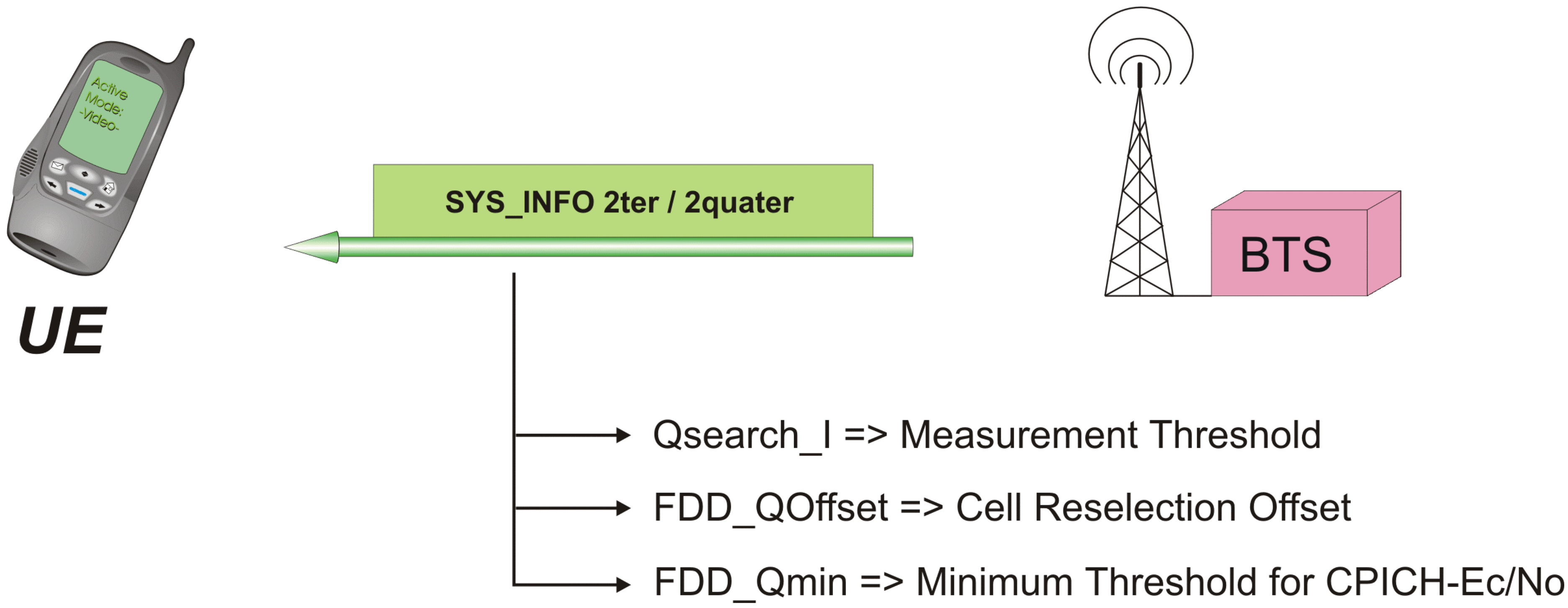
  For neighbor cells with the same HCS-priority timer Tn is only started, if:
  ⇒ Q-Rxlevmeas (neigh, n) > Q-Rxlevmeas(s) + Q-Offset-1-S-N
  or
  ⇒ Q-Qualmeas (neigh, n) > Q-Qualmeas(s) + Q-Offset-2-S-N
  Whether Q-Qualmeas or Q-Rxlevmeas is used, depends on the setting of the parameter CellSelectQualityMeasure.

- **The HCS-Priority of the current serving cell (SC) is equal to the HCS-priority of that neighbor cell**
  Note that the UE shall prefer measurements on NC's with equal or higher HCS-priority in an HCS-environment. Since the temporary offset does not apply, if the HCS-priority is different, this second condition will favorite cell reselections to higher priority neighbor cells than to neighbor cells with equal HCS-priority.

The Cell Ranking Criterion for the serving cell is identical to the one without HCS.

[3GTS 25.304 (5.2.6.1.4)]

Cell Reselection from GSM to UTRAN



Cell Reselection from GSM to UTRAN

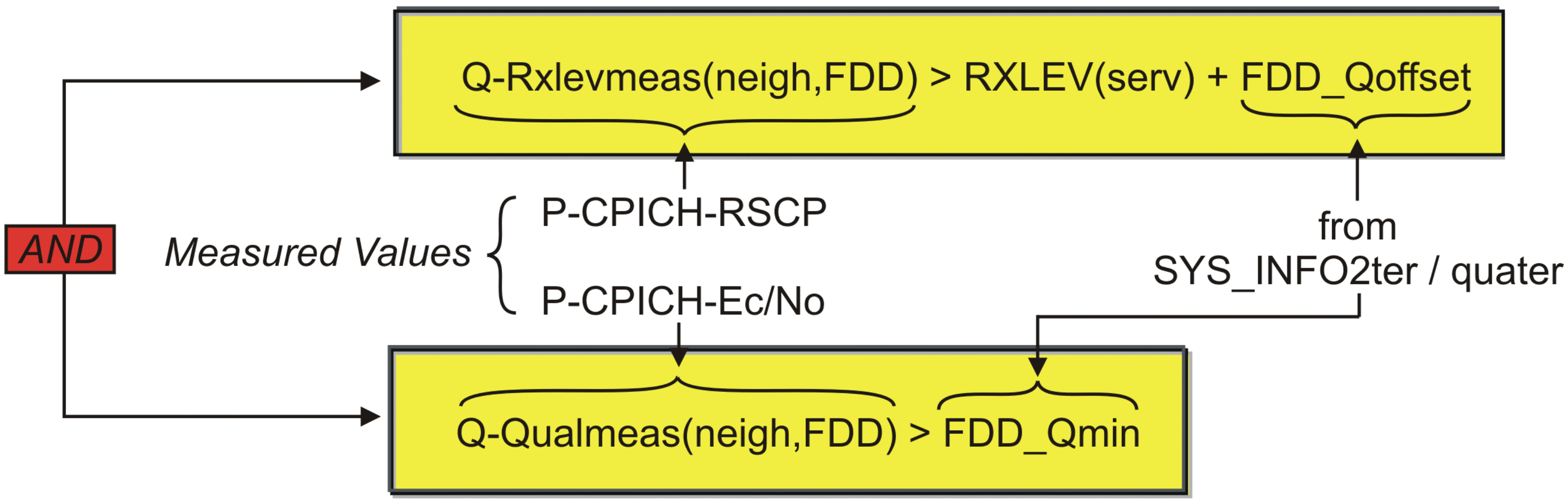
⇒ While the multi-mode UE is camping on a GSM-cell, it may receive (if the network supports it) 3G neighbor cell information plus the necessary cell reselection criteria through the SYS_INFO2ter- and SYS_INFO2quater-messages.

⇒ The most important parameters in addition to the plain 3G neighbor cell description (UARFCN and Primary Scrambling Code) are the parameters Qsearch_I, FDD_Qoffset and FDD_Qmin.

⇒ These parameters are used as offset during cell reselection (⇔ FDD_Qoffset), as measurement threshold (⇔ Qsearch_I) and as minimum requirement for the CPICH-Ec/No for an FDD-neighbor cell to become the new serving cell.

[3GTS 05.08 (6.6.4), 3GTS 04.18 (10.5.2.33a), 3GTS 04.18 (10.5.2.33b)]

Cell Reselection Criterion



Cell Reselection Criterion

While camping on a GSM-cell, the indicated cell reselection criterion applies for potential cell reselections towards a UTRA-FDD-cell.
Actually, there are two different conditions:

1. **The measurement value for the CPICH-RSCP of that UTRA-FDD neighbor cell needs to be higher than the RXLEV-measurement value of the serving GSM-cell or any other GSM-neighbor cell plus an individual cell offset, named FDD_Qoffset.**

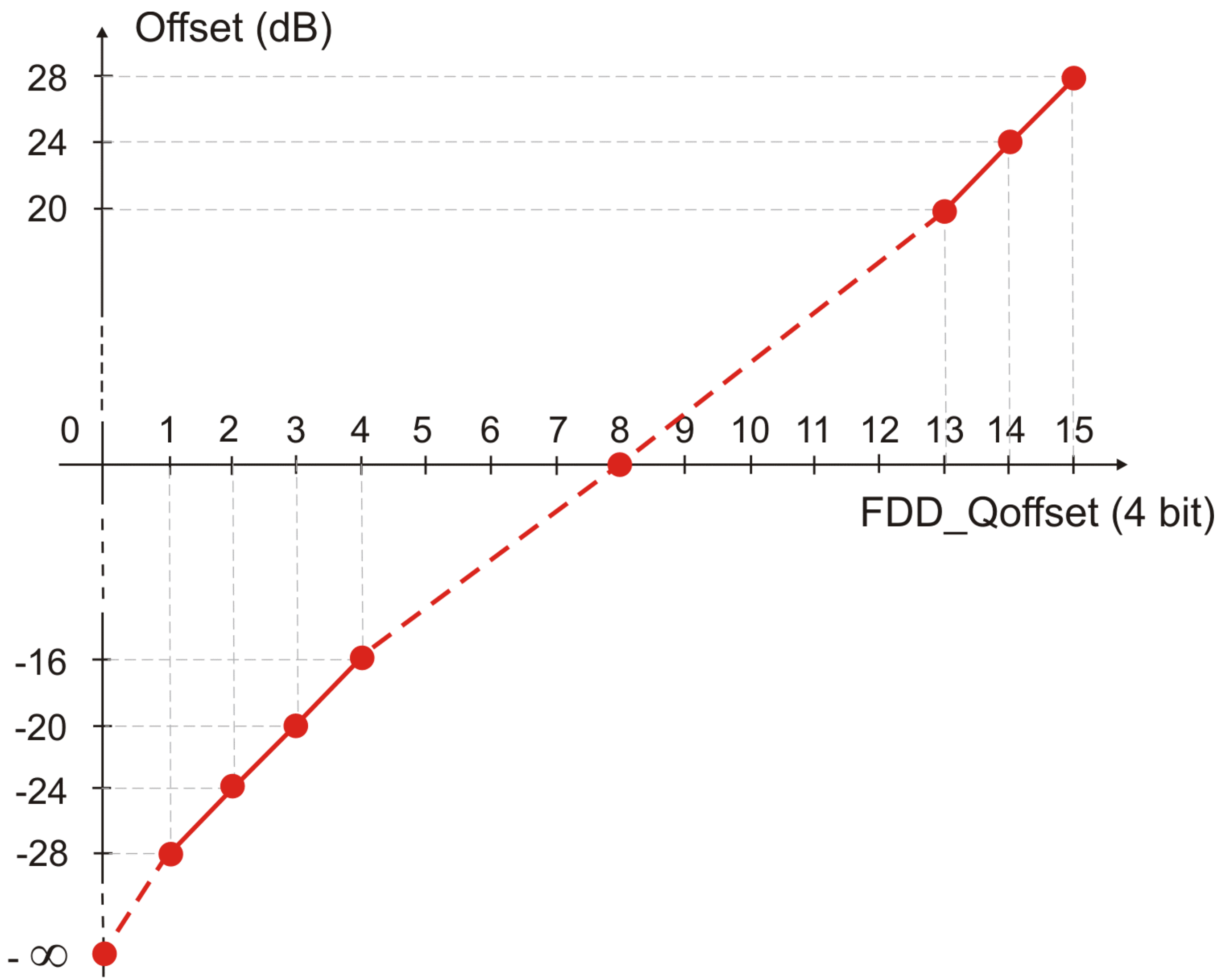
   FDD_Qoffset can be positive or negative and even be set to -∞ to enforce cell reselections towards any suitable UTRA-cell. For the first 15 seconds while camping on a GSM-cell, an additional 5 dB needs to be added to the broadcast value of FDD_Qoffset. More details on FDD_Qoffset are provided on the next slide.
   The above condition needs to be fulfilled for 5 s before the UE needs to check whether the second condition is also fulfilled.

2. **The measurement value for the CPICH-Ec/No of that UTRA-FDD neighbor cell needs to exceed FDD_Qmin.**

   FDD_Qmin is 3 bit long and defines a minimum threshold for the CPICH-Ec/No-value of the potential UTRA-FDD neighbor cell.
   The value range is 0 = -20 dB, 1 = -19 dB, 2 = -18 dB, 3 = -17 dB, 4 = -16 dB, 5 = -15 dB, 6 = -14 dB, 7 = -13 dB. The default value is -20 dB.
   FDD_Qmin is optionally broadcast on the GSM-BCCH in SYS_INFO2ter and SYS_INFO2quater

[3GTS 05.08 (6.6.5), (9)]

FDD_Qoffset


Offset (dB)
28
24
20
0
-16
-20
-24
-28
- ∞
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
FDD_Qoffset (4 bit)

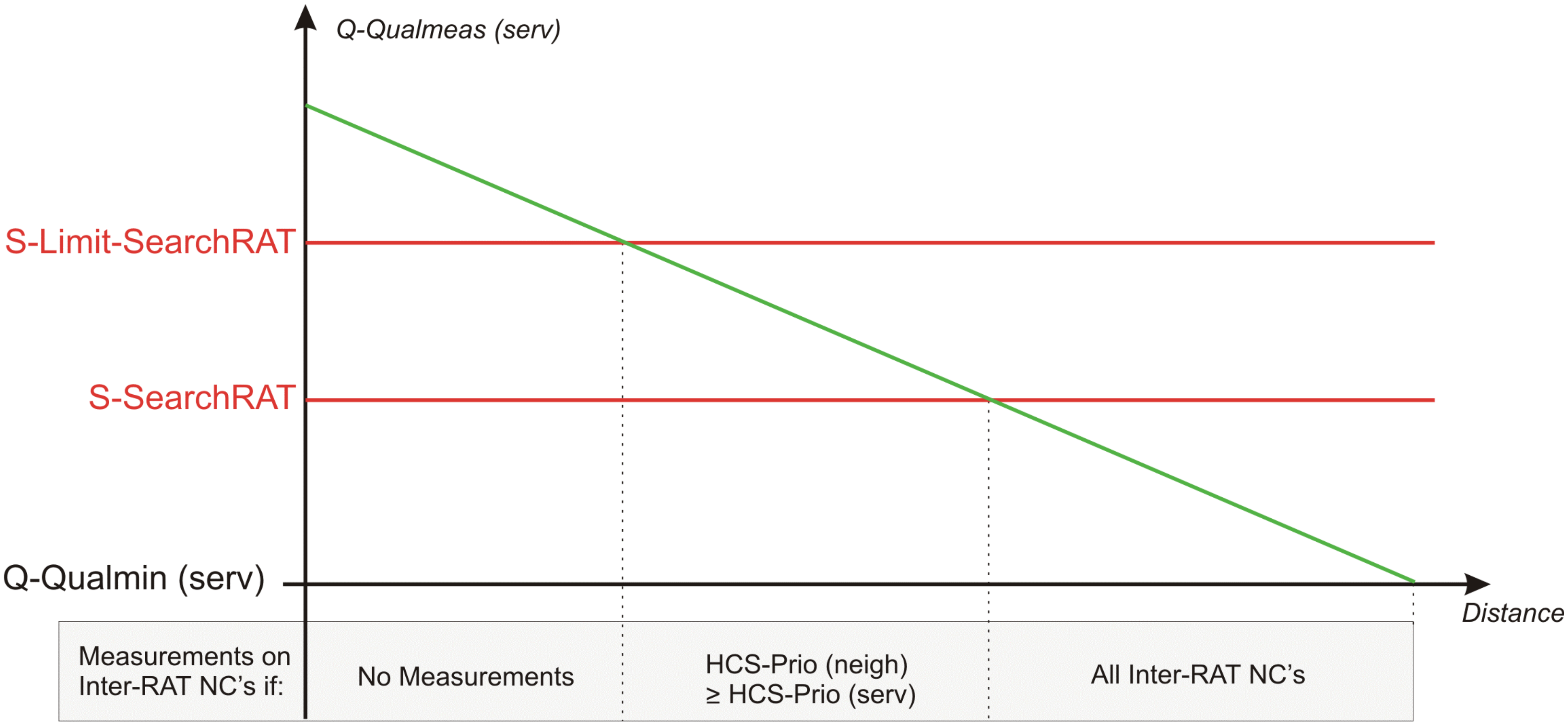
FDD_Qoffset

- ⇒ The value range of the 4 bit long parameter FDD_Qoffset and the related offset values in dB are illustrated in the figure.
- ⇒ Most importantly, FDD_Qoffset may be set to FDD_Qoffset = 0 which relates to an offset of -∞ dB. The consequence is that the UE will select *any* available UTRA-FDD neighbor cell of the serving GSM-cell, provided that the FDD_Qmin requirement is also met.
- ⇒ The figure also illustrates that the network operator may use other negative offset values from -28 dB to -4 dB with a step size of 4 dB (FDD_Qoffset = 1 – 7). Obviously, these negative values will also privilege cell reselections towards a UTRA-FDD neighbor cell.
- ⇒ FDD_Qoffset = 8 is the default value which also applies, if FDD_Qoffset is not broadcast in a GSM-cell.
- ⇒ The remaining values (FDD_Qoffset = 9 – 15) assign positive offset values and tendentiously discourage cell reselections to UTRA-FDD neighbor cells.

Note that FDD_Qoffset cannot be allocated individually per UTRA-FDD neighbor cell but it applies for all UTRA-FDD neighbor cells of one GSM-cell. Implementation depending, FDD_Qoffset may individually be assigned per GSM-cell.

[3GTS 04.18 (10.5.2.33a), (10.5.2.33b), 3GTS 05.08 (9)]

Setting up S-SearchRAT and S-Limit-SearchRAT



Setting up S-SearchRAT and S-Limit-SearchRAT

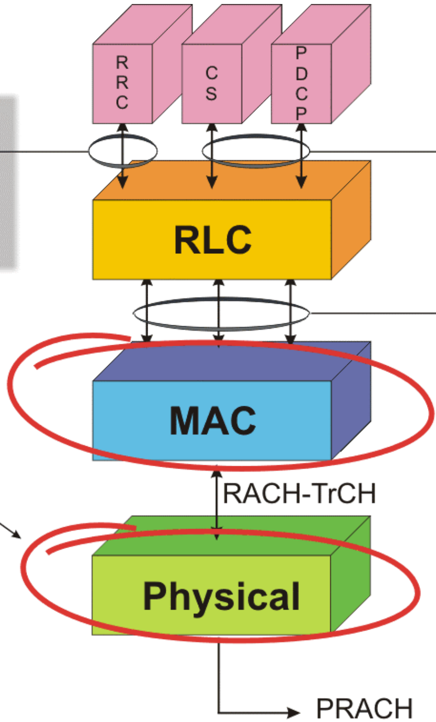
In an HCS-environment, the setup of S-SearchRAT and S-Limit-SearchRAT is related to each other. As the figure illustrates:

- **The UE shall not measure any inter-RAT neighbor cells (⇔ GSM) while Q-Qualmeas > S-Limit-SearchRAT.**
- **The UE shall measure inter-RAT neighbor cells with higher *and* equal HCS-priority while S-Limit-SearchRAT > Q-Qualmeas > S-SearchRAT.**
- **The UE shall measure all inter-RAT neighbor cells, irrespective of their HCS-priority while Q-Qualmeas < S-SearchRAT.**

Consequentially, S-Limit-SearchRAT needs to be configured at an equal or higher level than S-SearchRAT but never at a lower level

The Random Access Procedure

RACH as TrCH for SRB 0, 1, 2, 3 or 4.
Two cases to be distinguished:
a) for RRC_CONN_REQ, the ASC (Access Service Class) is determined from the Access Class.
b) for all other cases, the ASC is determined from the MLP



RACH as TrCH is QoS-dependent.
ASC equals assigned MLP (MAC Logical Channel Priority)

Different Logical Channel Types (UL-CCCH, UL-DCCH, UL-DTCH)

Performs MAC Random Access Procedure:
⇒ ASC-Selection and Random Number R Determination
⇒ Call of Physical Random Access Procedure.

Performs Physical Random Access Procedure:
⇒ PRACH-Signature Selection
⇒ Access Slot Selection
⇒ Transmission of PRACH-Preambles
⇒ Listening to AICH to receive and report positive or negative response.

The Random Access Procedure

The random access procedure always needs to be executed when the RACH-TrCH shall be used as transport channel for higher layer data.

Initial Conditions and Overview

The figure illustrates when the RACH-TrCH is used:

⇒ When the RRC-protocol needs to send an RRC_CONN_REQ-message in RRC-idle mode during the initial network access.

⇒ When the UE is in RRC-connected mode and needs to send a CELL_UPD- or URA_UPD-message over the SRB 0 (Signaling Radio Bearer).

⇒ When SRB's (Signaling Radio Bearers), CS-services (circuit-switched) or packet-switched services (PDCP) have previously been configured during a Radio Bearer Setup-procedure to use the RACH-TrCH.

The Random Access Procedure is split into two parts:

- **The MAC Random Access Procedure**
  The MAC-layer needs to be informed by RRC about the priority level of the random access which is given through the ASC (Access Service Class). One of the major tasks of the MAC-layer is the determination of whether or not the invocation of the physical random access procedure is allowed in the first place. This is done through the generation of random numbers. Another important task of MAC is the selection of an appropriate transport format out the configured TFS.

- **The Physical Random Access Procedure**
  The physical layer controls all physical characteristics of the transmission of PRACH-signatures in slotted aloha fashion towards the destination cell. In addition, the physical layer needs to report positive or negative responses received from the destination cell on AICH to the MAC-layer.

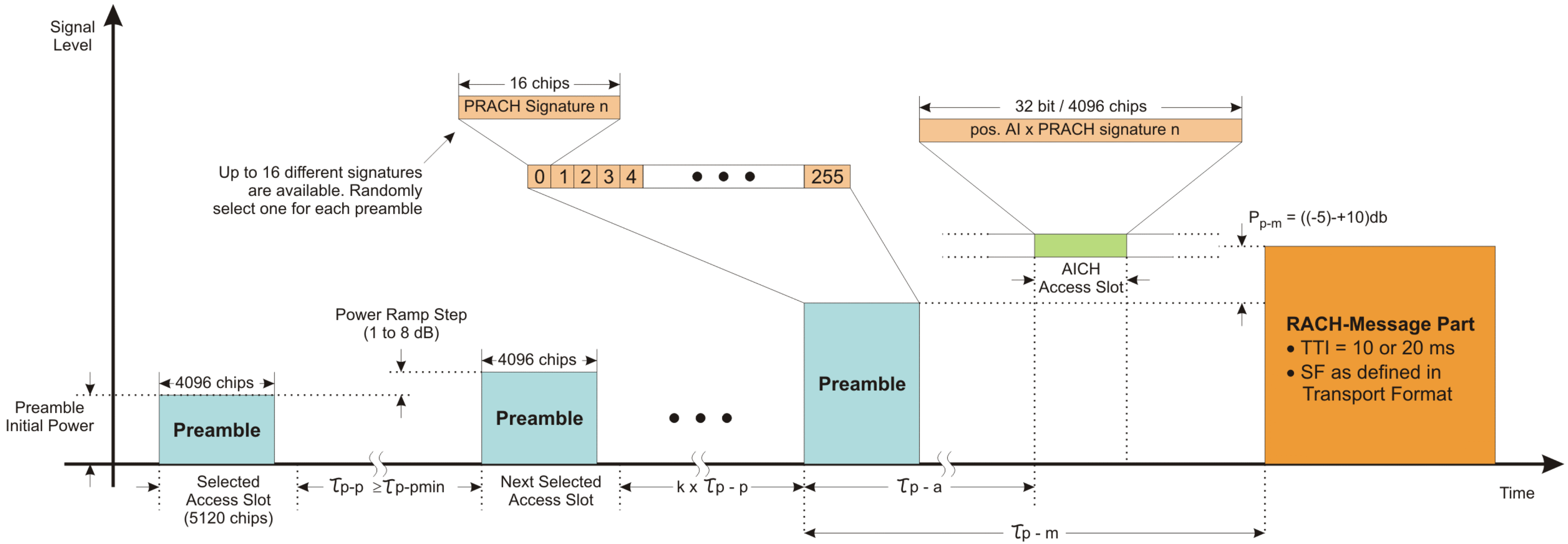
Details of the two parts will be provided on the following pages.

Note:

- On RACH-TrCH, only short information packages can be sent. The absolute length depends on the configured transport format (⇔ SIB5).
- Only the less sophisticated open loop power control procedure is applicable for the RACH (⇒ interference risk).
- Therefore, the use of RACH-TrCH for circuit-switched or packet-switched data transfer should only be considered for applications with very robust delay and reliability requirements (or, like RRC, the application deploys its own reliability scheme).

[3GTS 25.321 (11.2)]

The Physical Random Access Procedure



The Physical Random Access Procedure

⇒ The UE will randomly select one PRACH signature (according to SIB 5) and one PRACH subchannel. Then the UE will convey 256 repetitions of this PRACH-signature as initial PRACH access preamble with "Preamble Initial Power" and wait for an acquisition indication on AICH τp-a chips after the start of the access preamble transmission.

⇒ If there is no positive nor negative acquisition indication received by the UE, the UE will randomly select another signature and another subchannel number. This new preamble is transmitted with a power level that is "Power Ramp Step" higher than the previous transmission. The minimum time difference between any two preambles is determined through the parameter τp-p(min).

Note: The UE will never exceed a certain maximum transmit output power by more than 6 dB. This parameter (UE_TXPWR_MAX_RACH) it receives in SYS_INFO_TYPE3. Obviously, the UE may also not exceed its own maximum output power level which depends on the UE's output power class.

⇒ Eventually, the UE needs to receive a positive acquisition indication on AICH. Otherwise:
⇒ If the UE either exceeds the maximum uplink output power level (given through UE_TXPWR_MAX_RACH) by more than 6 dB
or
⇒ If the UE has transmitted the maximum number of PRACH-preambles during one preamble ramping cycle without receiving a response on AICH,
the UE shall report an unsuccessful outcome of the physical random access procedure to the MAC-layer.

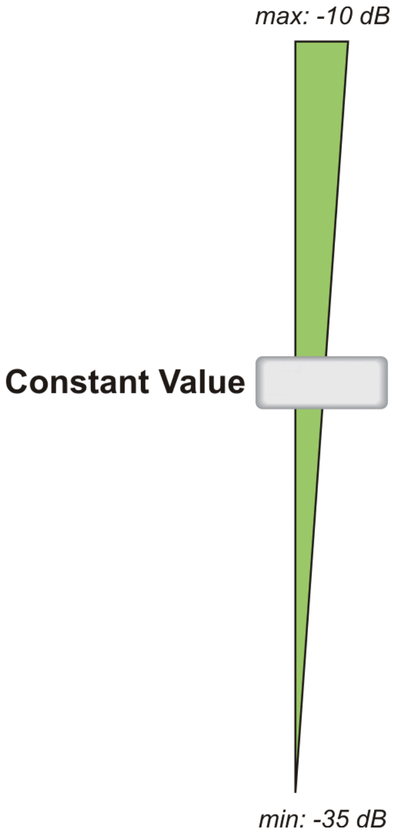
⇒ However, if a positive response is received from the NodeB, this positive acquisition indication needs to be received exactly τp-a chips after the start of the access preamble transmission.

⇒ Having received the positive acquisition indication, the UE will start transmitting the RACH-message part exactly τp-m chips after the start of the access preamble transmission. Note that the power level between the final access preamble and the RACH-message part is controlled by the parameter Pp-m.

⇒ The length of RACH-message part (10 ms and/or 20 ms) is like the transport format set for the RACH defined in SIB 5.

[3GTS 25.214 (6.1), 3GTS 25.321 (11.2.2)]

Setting up the Parameter Constant Value



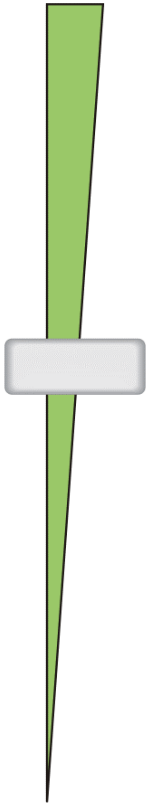
- **If the constant value is setup in the upper range (app. –10 dB), the risk of overshooting PRACH-preambles and therefore of increasing UL-Interference rises.**
- **If the constant value is setup in the lower range (app. –35 dB), UE's will in average need to transmit more (too many?) PRACH-preambles before they can be received by the NodeB. However, the UL-interference will be lower.**

Setting up the Parameter Constant Value

- **If the constant value is setup in the upper range (app. –10 dB), the risk of overshooting PRACH-preambles and therefore of increasing UL-Interference rises.**
  Obviously, higher values than –10 dB (e.g. –5 dB) are not even in the range of "Constant Value" because of the inaccurate behavior of the UE's which may result in errors of +/- 12 dB.
  If the network operator determines that the "Constant Value" should be setup around –10 dB – (-15 dB) then the parameter "Power Ramp Step" should be setup in the lower range (app. 1 dB – 2 dB) to minimize the resulting interference ratio.
- **If the constant value is setup in the lower range (app. –35 dB), UE's will in average need to transmit more (too many?) PRACH-preambles before they can be received by the NodeB. However, the UL-interference will be lower.**
  The lower range is obviously appealing, if the UL-interference is already an issue in an area or cell. To still reduce the tendency of longer delay times, the network operator may want to configure larger "Power Ramp Step" values. Note that in case of heavy load this setup will still cause higher interference because of colliding PRACH-preambles. This problem can only be addressed through a related setup of the parameter UE_TXPWR_MAX_RACH.

  [3GTS 25.331 (10.3.6.11)]

Setting up the Parameter Power Ramp Step



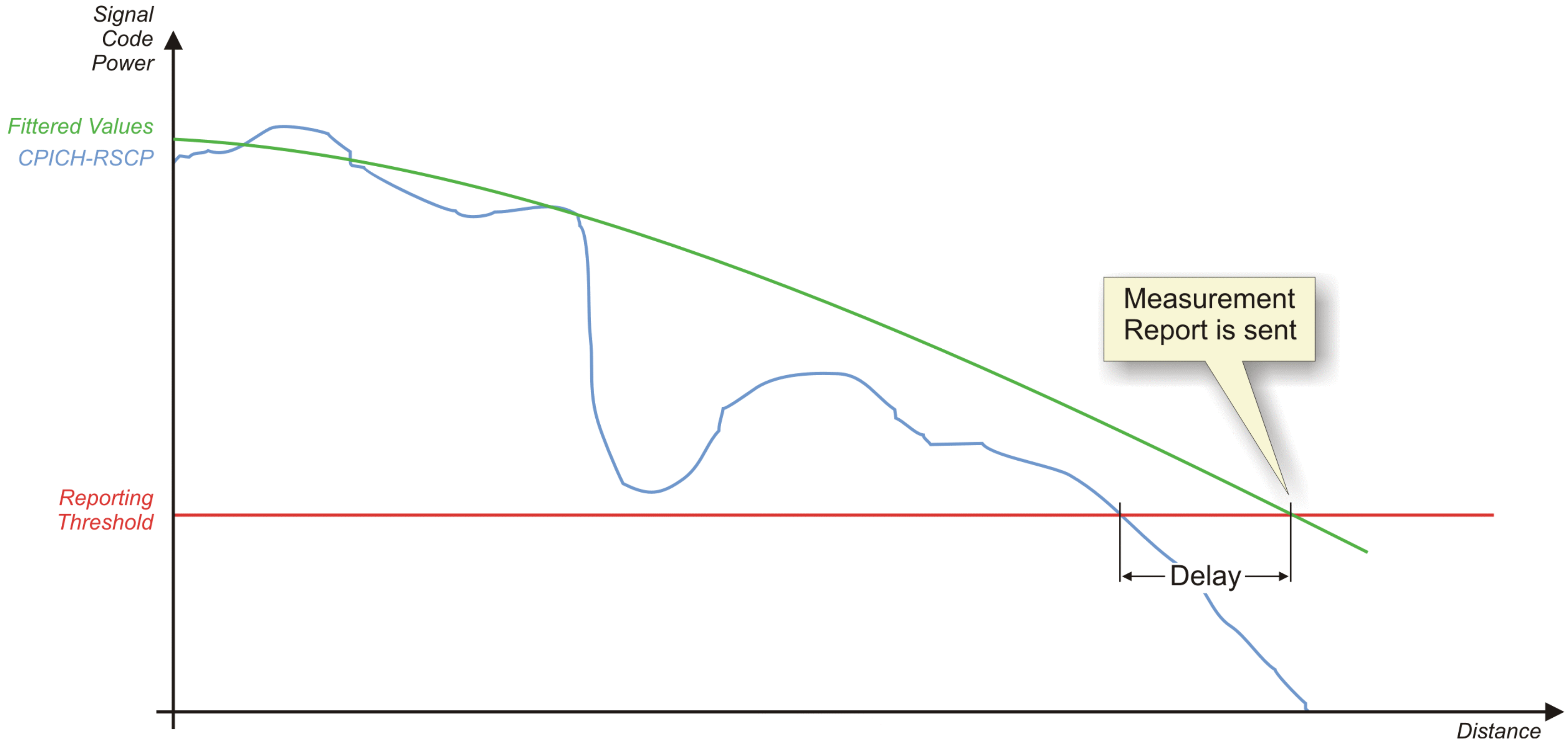
- **If the power ramp step is setup in the upper range (4 dB – 8 dB), the uplink interference will tendentiously be increasing, however the UE's will sooner exceed the noise level with one preamble.**
- **If the power ramp step is setup in the lower range (1dB – 3 dB), the UE's need to tendentiously transmit more preambles before they are "heard" by the network. Although the UL-interference is decreased, the network access time is tendentiously increased.**

Setting up the Parameter Power Ramp Step

- **If the power ramp step is setup in the upper range (4 dB – 8 dB), the uplink interference will tendentiously be increasing, however the UE's will sooner exceed the noise level with one preamble.**
  Setting up the parameter "Power Ramp Step" in the upper range may make sense, if the constant value is setup close to its extreme negative value to exceed the noise level with a minimum number of preambles. However, the preambles will in this case overshoot the noise level unnecessarily which in turn will increase the interference level.
- **If the power ramp step is setup in the lower range (1dB – 3 dB), the UE's need to tendentiously transmit more preambles before they are "heard" by the network. Although the UL-interference is decreased, the network access time is tendentiously increased.**
  Although the network access time may be tendentiously increased, this liability can be coped with if the parameter "Constant Value" is suitably setup (app. –12 dB). In this case, the initial preamble should already be close to the noise level so that a minimum number of preambles should be sufficient to exceed the noise level.

[3GTS 25.331 (10.3.6.54)]

Filtering


Signal
Code
Power
Fittered Values
CPICH-RSCP
Measurement
Report is sent
Reporting
Threshold
Delay
Distance

Filtering

Measurement sample filtering in UMTS is performed to avoid that fast fading may lead to too many measurement reporting events. In addition, measurement sample filtering helps to recognize tendencies.
The filtering itself represents a low path filter that differently weighs the latest measurement sample Q-meas(sample) vs the already filtered measurement result of all previous measurement samples.

$$Q\text{-}meas(n) = (1 - \alpha) \times Q\text{-}meas(n-1) + \alpha \times Q\text{-}meas(sample)$$

$$\alpha = 0.5\ EXP\ (fc/2)$$

The parameter α depends only on the filter coefficient "fc" which is conveyed to the UE using the MEAS_CTRL-message or SIB 11 / 12. The following table illustrates α-values in relation to "fc".

Filter Coefficient	α
0 (Default)	1
1	0.70711
2	0.5
3	0.35355
4	0.25
5	0.17678
6	0.125

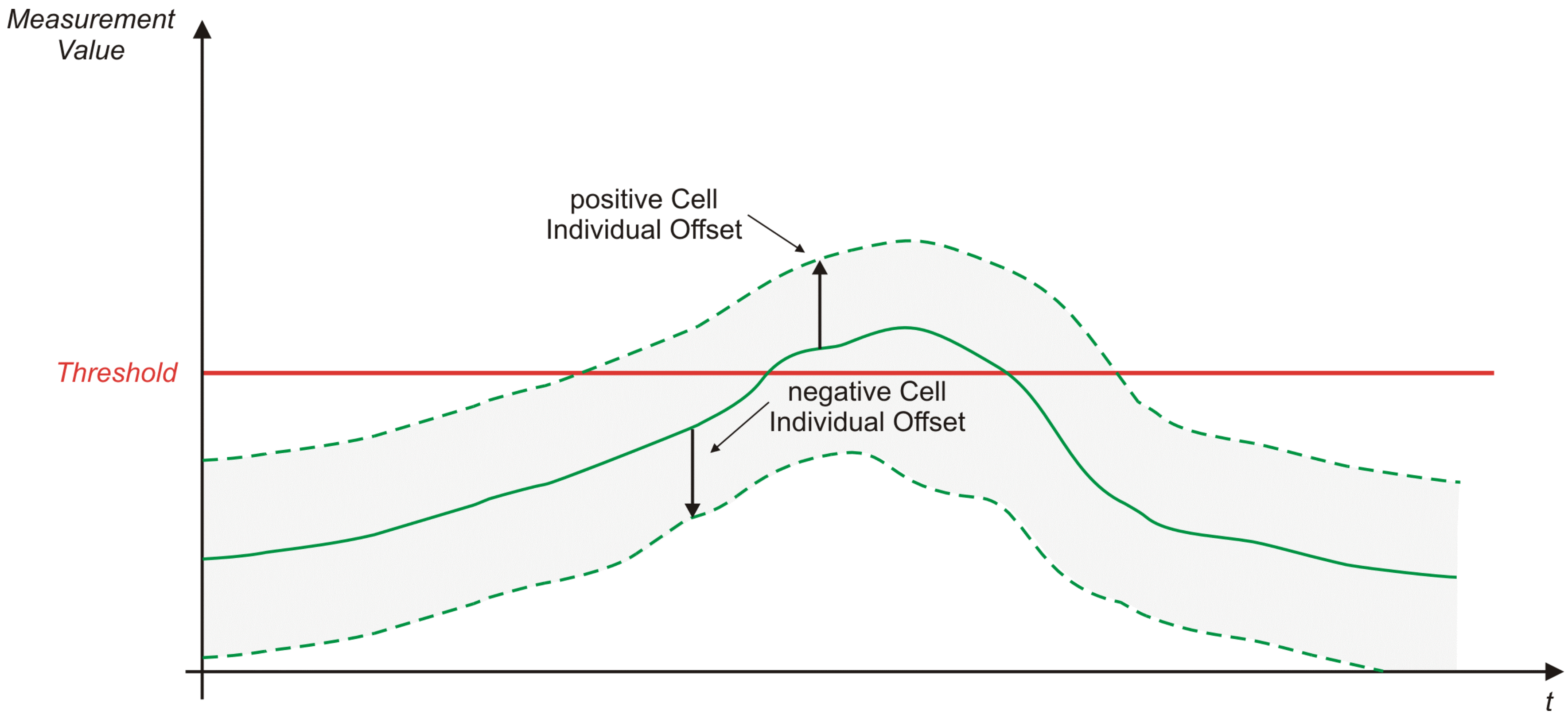
Filter Coefficient	α
7	0.08839
8	0.0625
9	0.04419
11	0.0221
13	0.01105
15	0.00552
17	0.00276
19	0.00138

The interpretation of the table is as follows:

- The smaller the value of "fc", the less filtering is done and the stronger is the impact of the latest measurement sample. With fc = 0, no filtering is done and Q-meas(n) only depends on the latest measurement sample Q-meas(sample).
- If fc = 19, the strongest filtering applies. The latest measurement sample provides little more than 1/1000 to Q-meas(n).

[3GTS 25.331 (8.6.7.2)]

Cell Individual Offsets (CIO)



Cell Individual Offsets (CIO)

One of the most important parameters for measurement control are the cell individual offsets which, as the name suggest, can be configured independently per neighbor cell and measurement type (⇔ intra-frequency, inter-frequency and inter-RAT). Through the cell individual offset, the respective measurement quantity (CPICH-Ec/No, CPICH-RSCP) of that neighbor cell can be positively or negatively offset.
The cell individual offset may be positive or negative or zero with a value range from -10 dB to +10 dB (step-size 0.5 dB) depending on the desired result:

- **Positive Cell Individual Offset**
  Tendentiously, a positive cell individual offset will encourage an event to occur. The event occurs earlier. If periodical measurement reporting is configured, the cell individual offset is added to the actual measurement sample.
  Positive cell individual offsets should be used for instance when a new neighbor cell becomes visible for the UE e.g. in a tunnel with the current serving cells fading out very fast. Enabled by the cell individual offset, the UE will report the new neighbor cell which in turn will be added to the active set by the RNC before the connection drops.

- **Negative Cell Individual Offset**
  Negative cell individual offsets discourage an event to occur. This makes sense if a neighbor cell should be added to the active set only in certain areas of the serving cell when the signal level of that neighbor cell is reliably strong and not fading out.

[3GTS 25.331 (10.3.7.2), (14.1.5.3)]

▪ *Index:*

#

A

B

C

D

E

F

H

I

L

M

N

O

P

Q

R

S

T

U

W