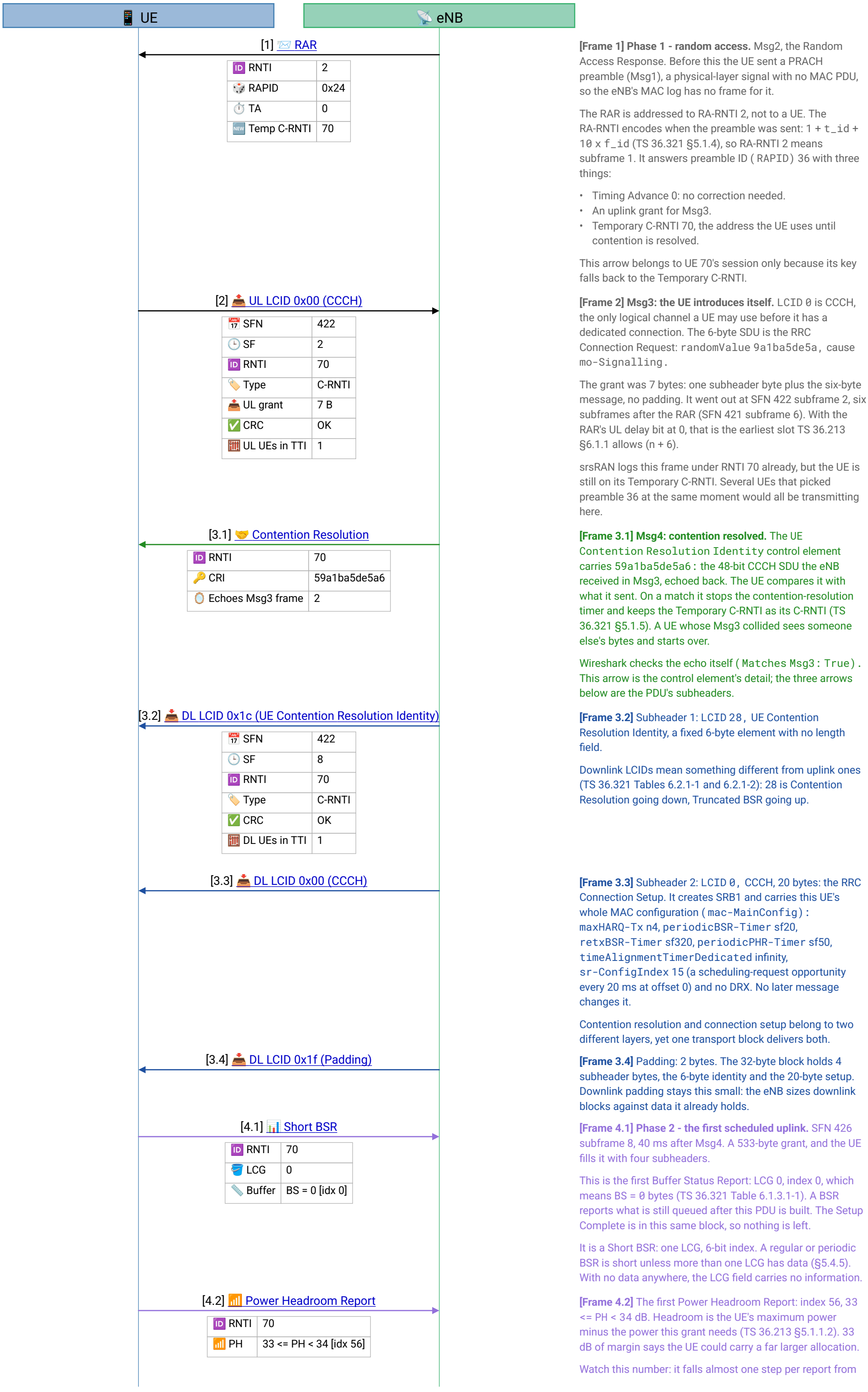
lte-mac-ue.annotated



[Frame 1] Phase 1 - random access. Msg2, the Random Access Response. Before this the UE sent a PRACH preamble (Msg1), a physical-layer signal with no MAC PDU, so the eNB's MAC log has no frame for it.

The RAR is addressed to RA-RNTI 2, not to a UE. The RA-RNTI encodes when the preamble was sent: `1 + t_id + 10 x f_id` (TS 36.321 §5.1.4), so RA-RNTI 2 means subframe 1. It answers preamble ID (`RAPID`) 36 with three things:

- Timing Advance 0: no correction needed.
- An uplink grant for Msg3.
- Temporary C-RNTI 70, the address the UE uses until contention is resolved.

This arrow belongs to UE 70's session only because its key falls back to the Temporary C-RNTI.

[Frame 2] Msg3: the UE introduces itself. `LCID 0` is CCCH, the only logical channel a UE may use before it has a dedicated connection. The 6-byte SDU is the RRC Connection Request: `randomValue 9a1ba5de5a`, cause `mo-Signalling`.

The grant was 7 bytes: one subheader byte plus the six-byte message, no padding. It went out at SFN 422 subframe 2, six subframes after the RAR (SFN 421 subframe 6). With the RAR's UL delay bit at 0, that is the earliest slot TS 36.213 §6.1.1 allows (n + 6).

srsRAN logs this frame under RNTI 70 already, but the UE is still on its Temporary C-RNTI. Several UEs that picked preamble 36 at the same moment would all be transmitting here.

[Frame 3.1] Msg4: contention resolved. The UE `Contention Resolution Identity` control element carries `59a1ba5de5a6`: the 48-bit CCCH SDU the eNB received in Msg3, echoed back. The UE compares it with what it sent. On a match it stops the contention-resolution timer and keeps the Temporary C-RNTI as its C-RNTI (TS 36.321 §5.1.5). A UE whose Msg3 collided sees someone else's bytes and starts over.

Wireshark checks the echo itself (`Matches Msg3: True`). This arrow is the control element's detail; the three arrows below are the PDU's subheaders.

[Frame 3.2] Subheader 1: `LCID 28`, UE Contention Resolution Identity, a fixed 6-byte element with no length field.

Downlink LCIDs mean something different from uplink ones (TS 36.321 Tables 6.2.1-1 and 6.2.1-2): 28 is Contention Resolution going down, Truncated BSR going up.

[Frame 3.3] Subheader 2: `LCID 0`, CCCH, 20 bytes: the RRC Connection Setup. It creates SRB1 and carries this UE's whole MAC configuration (`mac-MainConfig`): `maxHARQ-Tx` n4, `periodicBSR-Timer` sf20, `retxBSR-Timer` sf320, `periodicPHR-Timer` sf50, `timeAlignmentTimerDedicated` infinity, `sr-ConfigIndex` 15 (a scheduling-request opportunity every 20 ms at offset 0) and no DRX. No later message changes it.

Contention resolution and connection setup belong to two different layers, yet one transport block delivers both.

[Frame 3.4] Padding: 2 bytes. The 32-byte block holds 4 subheader bytes, the 6-byte identity and the 20-byte setup. Downlink padding stays this small: the eNB sizes downlink blocks against data it already holds.

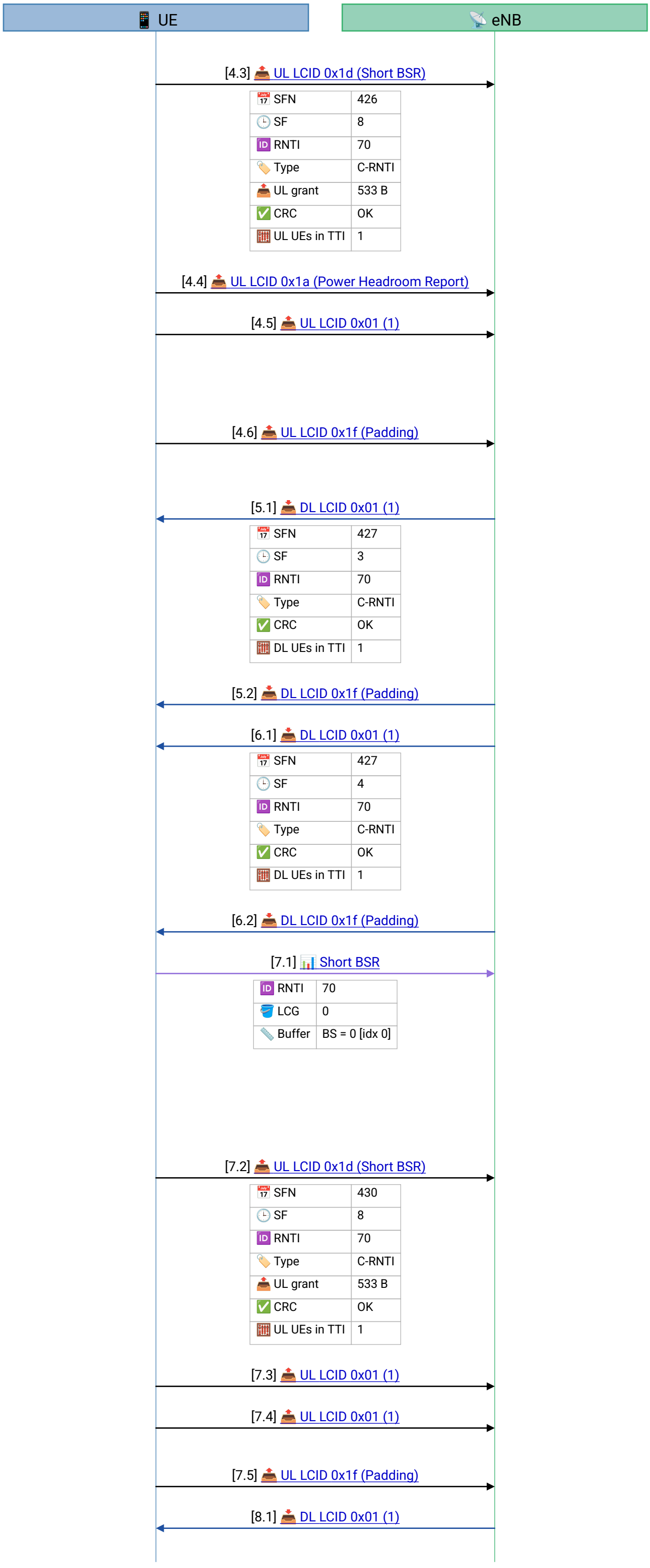
[Frame 4.1] Phase 2 - the first scheduled uplink. SFN 426 subframe 8, 40 ms after Msg4. A 533-byte grant, and the UE fills it with four subheaders.

This is the first Buffer Status Report: LCG 0, index 0, which means BS = `0` bytes (TS 36.321 Table 6.1.3.1-1). A BSR reports what is still queued after this PDU is built. The Setup Complete is in this same block, so nothing is left.

It is a Short BSR: one LCG, 6-bit index. A regular or periodic BSR is short unless more than one LCG has data (§5.4.5). With no data anywhere, the LCG field carries no information.

[Frame 4.2] The first Power Headroom Report: index 56, 33 <= PH < 34 dB. Headroom is the UE's maximum power minus the power this grant needs (TS 36.213 §5.1.1.2). 33 dB of margin says the UE could carry a far larger allocation.

Watch this number: it falls almost one step per report from



here, and is below zero by call 1.

[Frame 4.3] Subheader `LCID 29`, Short BSR. LTE lays out every subheader first, then the control-element bodies, then the SDUs, then padding (TS 36.321 §6.1.2). Control elements always come before SDUs, in both directions: no uplink PDU of UE 70 in the whole capture breaks the rule. (5G NR reverses it on the uplink.)

[Frame 4.4] Subheader `LCID 26`, Power Headroom Report. One byte, no length field.

[Frame 4.5] `LCID 1`, SRB1, 138 bytes: RLC AM `SN=0` carrying PDCP `SN=0`, the RRC Connection Setup Complete, and inside it the NAS Attach Request with a PDN Connectivity Request. To MAC it is 138 opaque bytes on logical channel 1. Its length needs the 15-bit length field, because it is over 127 bytes.

[Frame 4.6] Padding: 387 of the 533 granted bytes, 73% of the block. The eNB granted before it knew how big the message was, and MAC can't send a shorter block than granted. Uplink padding is the visible cost of that guess.

[Frame 5.1] The eNB's first downlink to the connected UE: `LCID 1`, 2 bytes, an RLC Status PDU (`ACK_SN=1`) acknowledging frame 4's RLC `SN=0`. The poll bit in frame 4 asked for it.

[Frame 5.2] Padding: 2 bytes close out the 7-byte downlink block.

[Frame 6.1] `LCID 1`, 13 bytes: RLC `SN=0` with the NAS Identity Request inside a DL Information Transfer. The NAS page reads it; here it is one SDU in an 18-byte block.

[Frame 6.2] Padding: 2 bytes close out the 18-byte downlink block.

[Frame 7.1] SFN 430 subframe 8: 40 ms after frame 4, again subframe 8 of an even-numbered frame. `sr-ConfigIndex` 15 puts a scheduling-request (SR) opportunity in subframe 0 of every even frame (TS 36.213 Table 10.1.5-1). In FDD an uplink grant applies four subframes after it is sent (TS 36.213 §8.0). So an SR at subframe 0, a grant at subframe 4 and this PUSCH at subframe 8 fit the timing exactly. The SR and the grant travel on PUCCH and PDCCH, which this MAC log doesn't record, so this is an inference from the timing.

Short BSR, LCG 0, BS = `0`. No PHR: only 40 ms since the last, and `periodicPHR-Timer` is 50 ms.

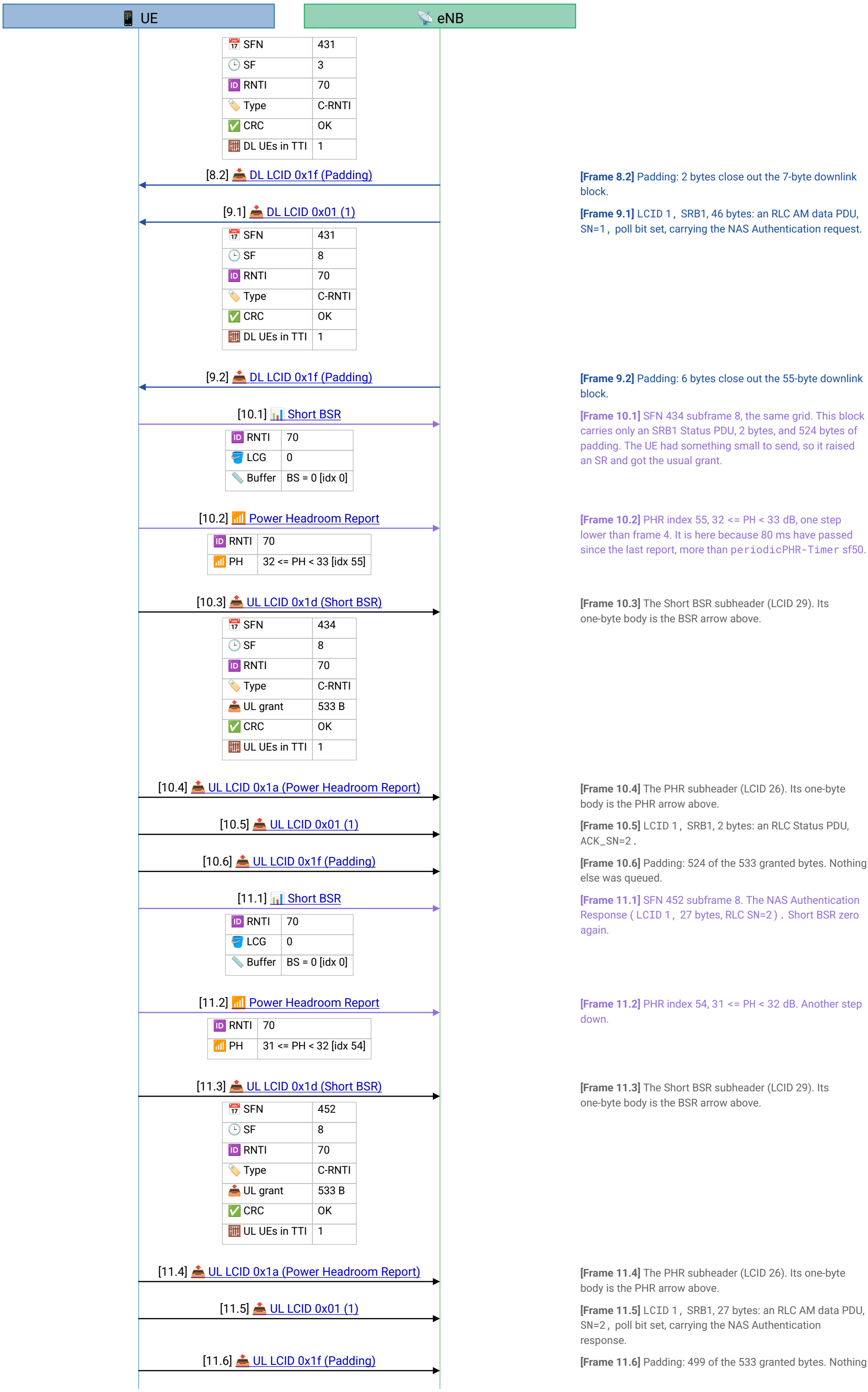
[Frame 7.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 7.3] `LCID 1`, 2 bytes: SRB1 Status PDU, `ACK_SN=1`, acknowledging the Identity Request.

[Frame 7.4] A second `LCID 1` SDU, 27 bytes: RLC `SN=1`, the NAS Identity Response. Two RLC PDUs of one logical channel, each with its own subheader.

[Frame 7.5] Padding: 497 of the 533 granted bytes. Nothing else was queued.

[Frame 8.1] `LCID 1`, SRB1, 2 bytes: an RLC Status PDU, `ACK_SN=2`.



[Frame 8.2] Padding: 2 bytes close out the 7-byte downlink block.

[Frame 9.1] `LCID 1`, SRB1, 46 bytes: an RLC AM data PDU, `SN=1`, poll bit set, carrying the NAS Authentication request.

[Frame 9.2] Padding: 6 bytes close out the 55-byte downlink block.

[Frame 10.1] SFN 434 subframe 8, the same grid. This block carries only an SRB1 Status PDU, 2 bytes, and 524 bytes of padding. The UE had something small to send, so it raised an SR and got the usual grant.

[Frame 10.2] PHR index 55, 32 <= PH < 33 dB, one step lower than frame 4. It is here because 80 ms have passed since the last report, more than `periodicPHR-Timer` sf50.

[Frame 10.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 10.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 10.5] `LCID 1`, SRB1, 2 bytes: an RLC Status PDU, `ACK_SN=2`.

[Frame 10.6] Padding: 524 of the 533 granted bytes. Nothing else was queued.

[Frame 11.1] SFN 452 subframe 8. The NAS Authentication Response (`LCID 1`, 27 bytes, RLC `SN=2`). Short BSR zero again.

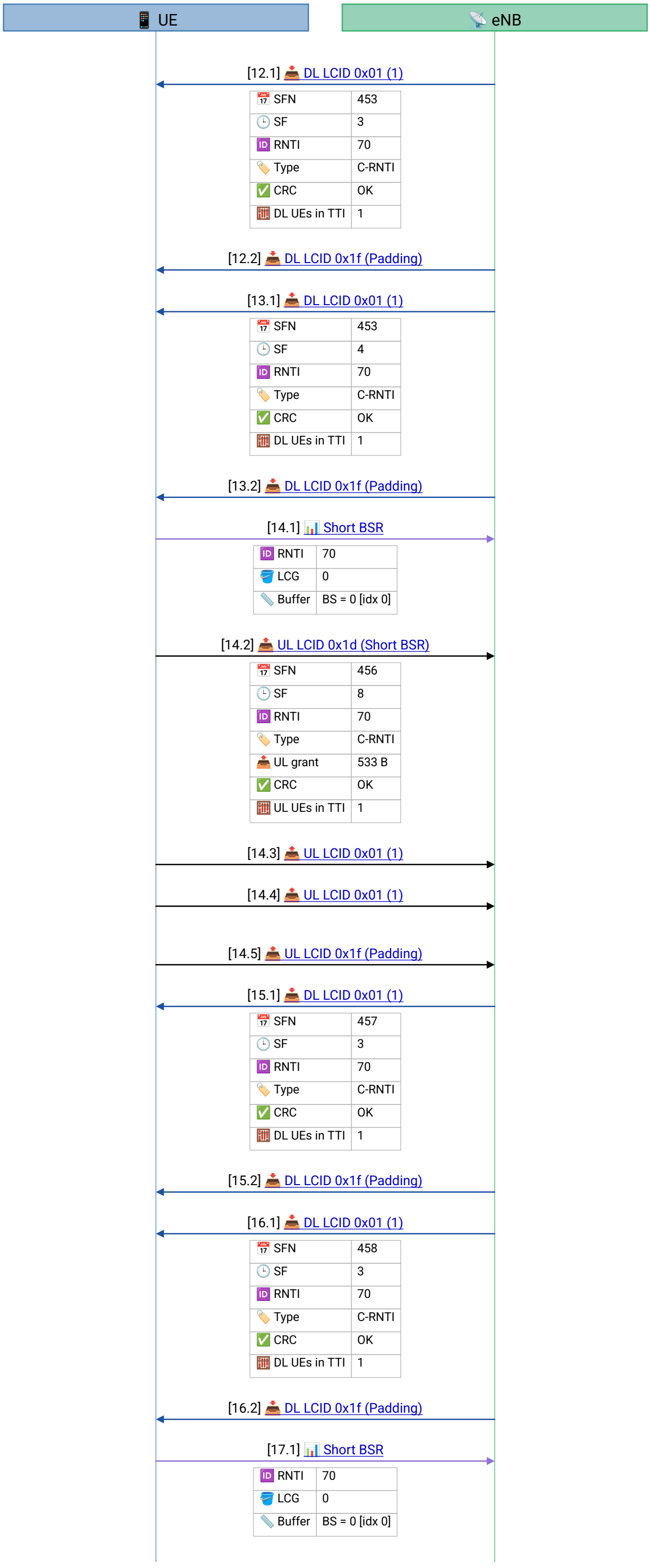
[Frame 11.2] PHR index 54, 31 <= PH < 32 dB. Another step down.

[Frame 11.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 11.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 11.5] `LCID 1`, SRB1, 27 bytes: an RLC AM data PDU, `SN=2`, poll bit set, carrying the NAS Authentication response.

[Frame 11.6] Padding: 499 of the 533 granted bytes. Nothing



else was queued.

[Frame 12.1] LCID 1, SRB1, 2 bytes: an RLC Status PDU, ACK_SN=3.

[Frame 12.2] Padding: 2 bytes close out the 7-byte downlink block.

[Frame 13.1] LCID 1, SRB1, 37 bytes: an RLC AM data PDU, SN=2, poll bit set, carrying the NAS Security mode command.

[Frame 13.2] Padding: 7 bytes close out the 47-byte downlink block.

[Frame 14.1] Short BSR: LCG 0, BS = 0 (index 0). Nothing left queued after this block.

[Frame 14.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 14.3] LCID 1, SRB1, 2 bytes: an RLC Status PDU, ACK_SN=3.

[Frame 14.4] LCID 1, SRB1, 29 bytes: an RLC AM data PDU, SN=3, poll bit set, carrying the NAS Security mode complete.

[Frame 14.5] Padding: 495 of the 533 granted bytes. Nothing else was queued.

[Frame 15.1] LCID 1, SRB1, 2 bytes: an RLC Status PDU, ACK_SN=4.

[Frame 15.2] Padding: 2 bytes close out the 7-byte downlink block.

[Frame 16.1] LCID 1, SRB1, 10 bytes: an RLC AM data PDU, SN=3, poll bit set, carrying the RRC Security Mode Command.

[Frame 16.2] Padding: 2 bytes close out the 15-byte downlink block.

[Frame 17.1] SFN 460 subframe 8: the RRC Security Mode Complete (LCID 1, 9 bytes) and a Status PDU. From here SRB1 PDUs carry a real integrity tag, but MAC can't tell: it still sees opaque bytes on logical channel 1.



[Frame 17.2] PHR index 53, `30 <= PH < 31` dB. Four reports, four steps down: 56, 55, 54, 53.

[Frame 17.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 17.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 17.5] `LCID 1, SRB1, 2 bytes: an RLC Status PDU, ACK_SN=4.`

[Frame 17.6] `LCID 1, SRB1, 9 bytes: an RLC AM data PDU, SN=4, poll bit set, carrying the RRC Security Mode Complete.`

[Frame 17.7] Padding: 513 of the 533 granted bytes. Nothing else was queued.

[Frame 18.1] `LCID 1, SRB1, 2 bytes: an RLC Status PDU, ACK_SN=5.`

[Frame 18.2] Padding: 2 bytes close out the 7-byte downlink block.

[Frame 19.1] `LCID 1, SRB1, 10 bytes: an RLC AM data PDU, SN=4, poll bit set, carrying the RRC UE Capability Enquiry.`

[Frame 19.2] Padding: 2 bytes close out the 15-byte downlink block.

[Frame 20.1] Phase 3 - a real backlog. The UE Capability Information is a 2,017-byte PDCP PDU, far too big for a 533-byte grant. RLC cuts it into segments, and this BSR is the first in the session that asks for something: LCG 0, index 33, 1326 < BS <= 1552 bytes still queued.

SRB1 belongs to LCG 0 by default (TS 36.331 §9.2.1.1). So the eNB now knows how much signaling data the UE holds, though not which channel it is on.

[Frame 20.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 20.3] `LCID 1, 2 bytes: SRB1 Status PDU, ACK_SN=5, acknowledging the Capability Enquiry.`

[Frame 20.4] `LCID 1, the rest of the block: the first RLC segment of the capability message, RLC SN=5. The last subheader has no length field: its SDU runs to the end. That is also why this block has no padding. 533 bytes granted, 533 used.`

[Frame 21] SFN 465 subframe 7, off the 20 ms grid. This is the eNB answering frame 20's BSR directly, with a 1,335-byte grant.



One subheader, one SDU: RLC SN=6, the middle segment, filling the whole block. No BSR, no PHR, no padding.

The PHR timer runs out at 50 ms, and this block sits at 49 ms after frame 17's report, so no PHR yet. The next block, one subframe later, has one.

[Frame 22.1] SFN 465 subframe 8, a 233-byte grant. The eNB granted 1,335 + 233 = 1,568 bytes against frame 20's report of at most 1,552. Together the two grants cover the reported range's upper end.

This BSR is a Long BSR: four 6-bit fields, one per LCG, all 0. A regular or periodic BSR is Long only when more than one LCG has data (TS 36.321 §5.4.5). This one reports none, so it must be a padding BSR: one sent because the padding had room for it, and padding with room for a Long BSR gets a Long BSR. The periodic timer can't have fired: frame 20's Short BSR restarted it 10 ms ago.

[Frame 22.2] PHR index 55, 32 <= PH < 33 dB. Exactly 50 subframes after frame 17's report: `periodicPHR-Timer` sf50 at work.

[Frame 22.3] Subheader `LCID 26`, PHR. Frame 4 put the BSR first; here the PHR leads. The rule that matters is that control elements come before SDUs.

[Frame 22.4] Subheader `LCID 30`, Long BSR. Three bytes, no length field.

[Frame 22.5] `LCID 1`, 163 bytes: RLC `SN=7`, the last segment. The 2,017-byte capability message is now complete: three RLC PDUs, three MAC PDUs, one PDCP SN.

[Frame 22.6] Padding: 60 bytes. The 233-byte grant was a close fit.

[Frame 23.1] `LCID 1`, SRB1, 2 bytes: an RLC Status PDU, `ACK_SN=8`.

[Frame 23.2] Padding: 2 bytes close out the 7-byte downlink block.

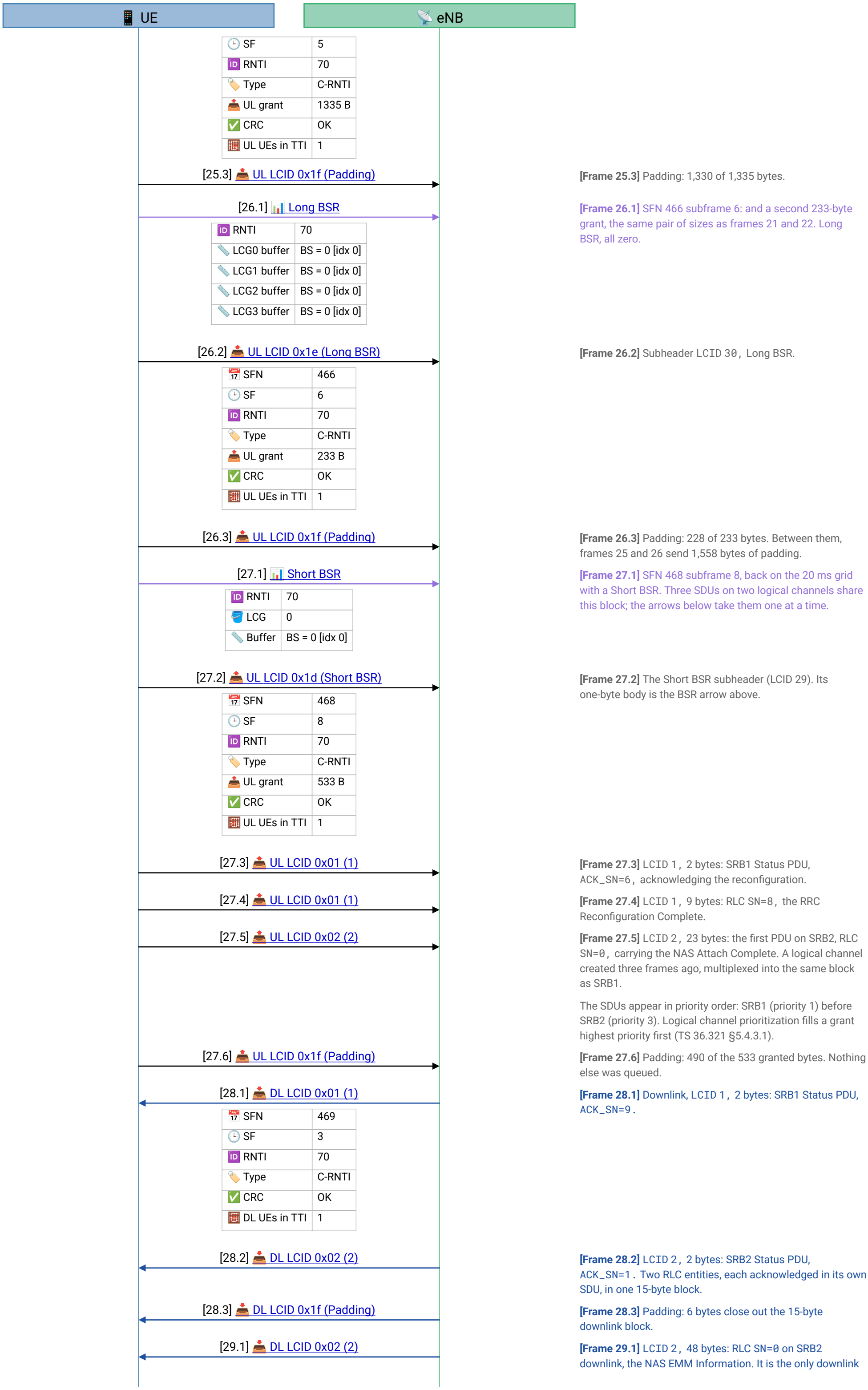
[Frame 24.1] `LCID 1`, 203 bytes: the first RRC Connection Reconfiguration, with the NAS Attach Accept inside. It adds SRB2 (`LCID 2`, default settings, so LCG 0) and DRB 1, the internet bearer: `LCID 3`, priority 11, `logicalChannelGroup` 3. From now on a BSR can report the internet bearer separately, under LCG 3. The RRC page reads the rest.

[Frame 24.2] Padding: 10 bytes close out the 217-byte downlink block.

[Frame 25.1] SFN 466 subframe 5: another 1,335-byte grant, and the UE has nothing to put in it. Frame 22 already reported zero.

These are not HARQ retransmissions of frames 21 and 22. A retransmission repeats the same bytes, and this block carries new content: a Long BSR and padding. The log doesn't say why the eNB granted again; one possibility is that it scheduled before it had processed frame 22's report. The UE has to fill the grant with something, so it sends a padding BSR, all zero.

[Frame 25.2] Subheader `LCID 30`, Long BSR.



[Frame 25.3] Padding: 1,330 of 1,335 bytes.

[Frame 26.1] SFN 466 subframe 6: and a second 233-byte grant, the same pair of sizes as frames 21 and 22. Long BSR, all zero.

[Frame 26.2] Subheader `LCID 30`, Long BSR.

[Frame 26.3] Padding: 228 of 233 bytes. Between them, frames 25 and 26 send 1,558 bytes of padding.

[Frame 27.1] SFN 468 subframe 8, back on the 20 ms grid with a Short BSR. Three SDUs on two logical channels share this block; the arrows below take them one at a time.

[Frame 27.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 27.3] `LCID 1`, 2 bytes: SRB1 Status PDU, `ACK_SN=6`, acknowledging the reconfiguration.

[Frame 27.4] `LCID 1`, 9 bytes: RLC `SN=8`, the RRC Reconfiguration Complete.

[Frame 27.5] `LCID 2`, 23 bytes: the first PDU on SRB2, RLC `SN=0`, carrying the NAS Attach Complete. A logical channel created three frames ago, multiplexed into the same block as SRB1.

The SDUs appear in priority order: SRB1 (priority 1) before SRB2 (priority 3). Logical channel prioritization fills a grant highest priority first (TS 36.321 §5.4.3.1).

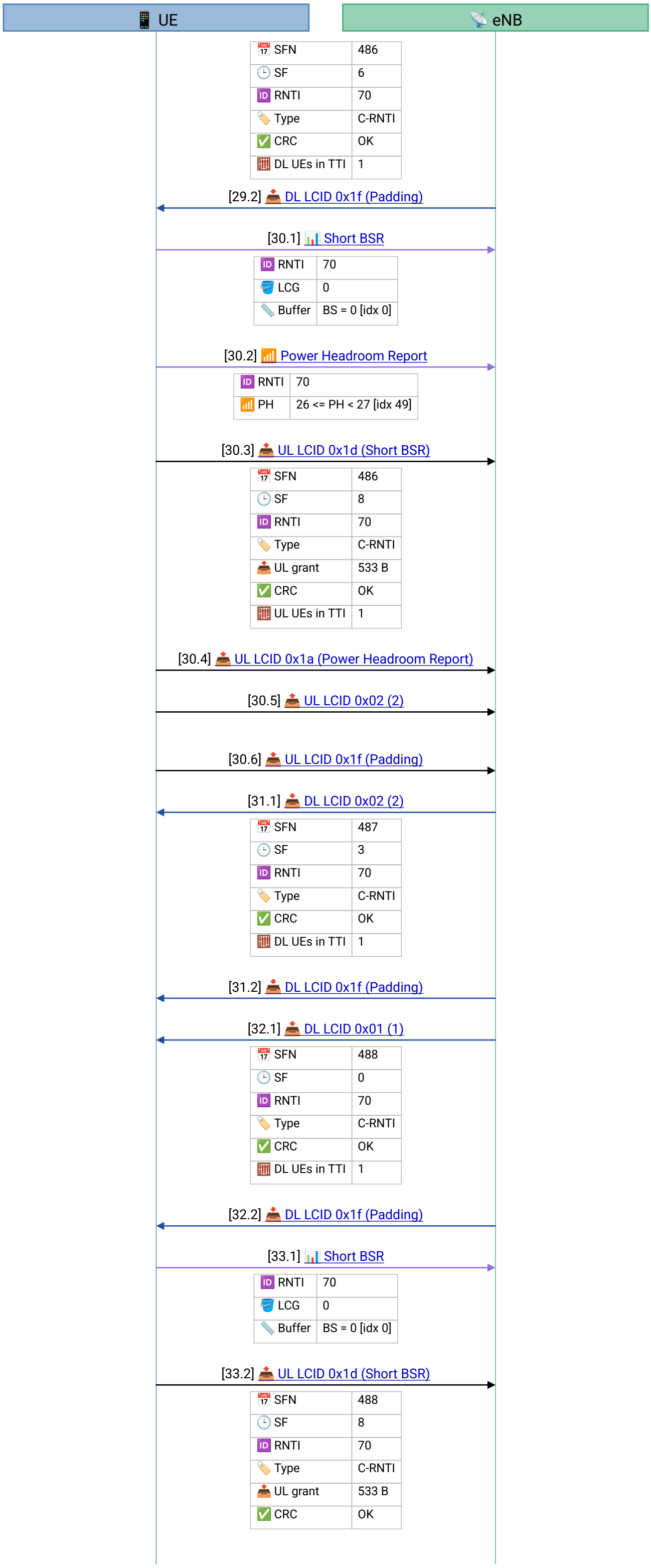
[Frame 27.6] Padding: 490 of the 533 granted bytes. Nothing else was queued.

[Frame 28.1] Downlink, `LCID 1`, 2 bytes: SRB1 Status PDU, `ACK_SN=9`.

[Frame 28.2] `LCID 2`, 2 bytes: SRB2 Status PDU, `ACK_SN=1`. Two RLC entities, each acknowledged in its own SDU, in one 15-byte block.

[Frame 28.3] Padding: 6 bytes close out the 15-byte downlink block.

[Frame 29.1] `LCID 2`, 48 bytes: RLC `SN=0` on SRB2 downlink, the NAS EMM Information. It is the only downlink



NAS message that ever travels on SRB2; later ones ride inside reconfigurations on SRB1.

[Frame 29.2] Padding: 4 bytes close out the 55-byte downlink block.

[Frame 30.1] SFN 486 subframe 8. LCID 2, 63 bytes: the PDN Connectivity Request for the IMS APN. Short BSR zero.

[Frame 30.2] PHR index 49, 26 <= PH < 27 dB. Down six steps since frame 22.

[Frame 30.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 30.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 30.5] LCID 2, SRB2, 63 bytes: an RLC AM data PDU, SN=1, poll bit set, carrying the NAS PDN connectivity request.

[Frame 30.6] Padding: 463 of the 533 granted bytes. Nothing else was queued.

[Frame 31.1] LCID 2, SRB2, 2 bytes: an RLC Status PDU, ACK_SN=2.

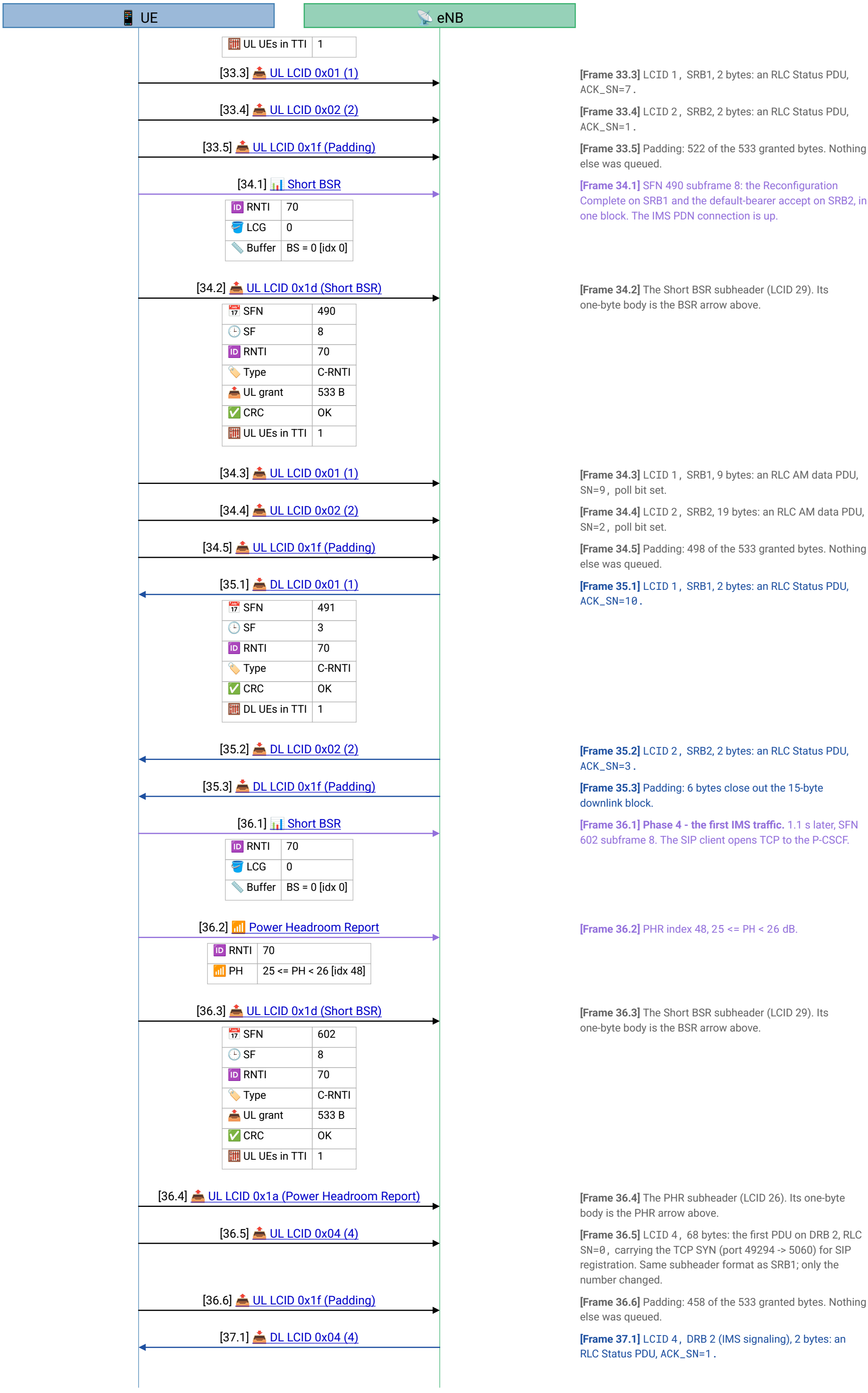
[Frame 31.2] Padding: 4 bytes close out the 9-byte downlink block.

[Frame 32.1] LCID 1, 140 bytes: the reconfiguration that adds DRB 2, the IMS signaling bearer: LCID 4, priority 11, logicalChannelGroup 2. Voice will later get LCG 1 and the internet bearer already has LCG 3, so each kind of traffic gets its own group.

[Frame 32.2] Padding: 5 bytes close out the 149-byte downlink block.

[Frame 33.1] Short BSR: LCG 0, BS = 0 (index 0). Nothing left queued after this block.

[Frame 33.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.



[Frame 33.3] LCID 1, SRB1, 2 bytes: an RLC Status PDU, ACK_SN=7.

[Frame 33.4] LCID 2, SRB2, 2 bytes: an RLC Status PDU, ACK_SN=1.

[Frame 33.5] Padding: 522 of the 533 granted bytes. Nothing else was queued.

[Frame 34.1] SFN 490 subframe 8: the Reconfiguration Complete on SRB1 and the default-bearer accept on SRB2, in one block. The IMS PDN connection is up.

[Frame 34.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 34.3] LCID 1, SRB1, 9 bytes: an RLC AM data PDU, SN=9, poll bit set.

[Frame 34.4] LCID 2, SRB2, 19 bytes: an RLC AM data PDU, SN=2, poll bit set.

[Frame 34.5] Padding: 498 of the 533 granted bytes. Nothing else was queued.

[Frame 35.1] LCID 1, SRB1, 2 bytes: an RLC Status PDU, ACK_SN=10.

[Frame 35.2] LCID 2, SRB2, 2 bytes: an RLC Status PDU, ACK_SN=3.

[Frame 35.3] Padding: 6 bytes close out the 15-byte downlink block.

[Frame 36.1] Phase 4 - the first IMS traffic. 1.1 s later, SFN 602 subframe 8. The SIP client opens TCP to the P-CSCF.

[Frame 36.2] PHR index 48, 25 <= PH < 26 dB.

[Frame 36.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 36.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 36.5] LCID 4, 68 bytes: the first PDU on DRB 2, RLC SN=0, carrying the TCP SYN (port 49294 -> 5060) for SIP registration. Same subheader format as SRB1; only the number changed.

[Frame 36.6] Padding: 458 of the 533 granted bytes. Nothing else was queued.

[Frame 37.1] LCID 4, DRB 2 (IMS signaling), 2 bytes: an RLC Status PDU, ACK_SN=1.



[Frame 37.2] Padding: 70 bytes close out the 75-byte downlink block.

[Frame 38.1] `LCID 4`, DRB 2 (IMS signaling), 64 bytes: an RLC AM data PDU, `SN=0`, poll bit set.

[Frame 38.2] Padding: 2 bytes close out the 69-byte downlink block.

[Frame 39.1] SFN 606 subframe 8. The SIP REGISTER is queued, and the BSR names **LCG 2** for the first time: index 32, 1132 < BS <= 1326 bytes. The eNB now knows this backlog is IMS signaling, not RRC: frame 32 put `LCID 4` in group 2.

[Frame 39.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 39.3] `LCID 4`, 2 bytes: DRB 2 Status PDU, `ACK_SN=1`.

[Frame 39.4] `LCID 4`, the rest of the block: RLC `SN=1`, holding a TCP ACK (PDCP SN 1) and the first 468 bytes of PDCP SN 2, which carries the REGISTER's first TCP segment (1,398 bytes). No padding: the block is full.

[Frame 40.1] SFN 607 subframe 7, a 1,335-byte grant 9 ms after the report, off the 20 ms grid. Another Long BSR, but this one is not empty: LCG 2 at index 22, 234 < BS <= 274 bytes still queued.

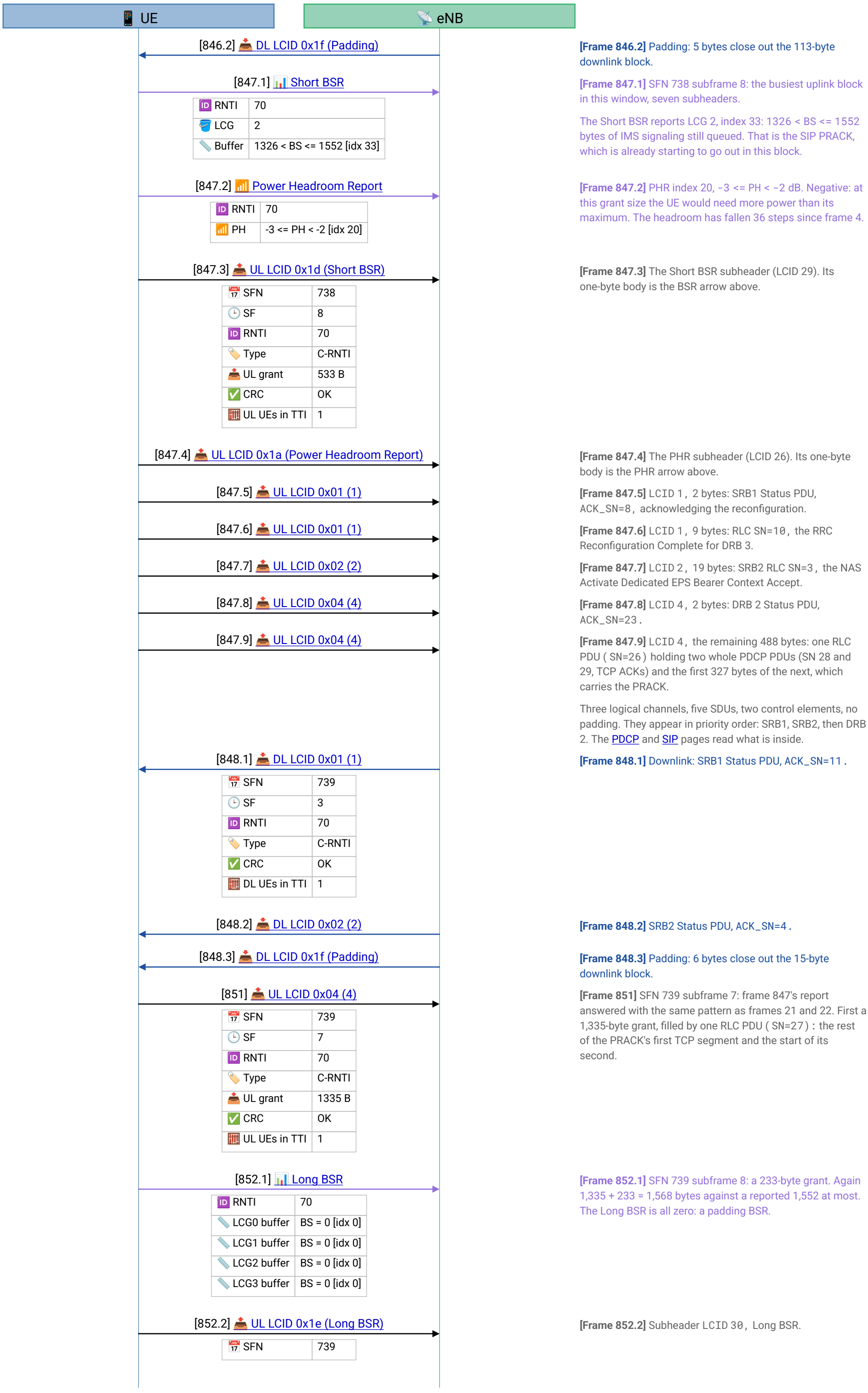
It is Long with only one group non-zero, so it is again a padding BSR. Yet the block also carries 341 bytes of padding while the UE reports data waiting. The eNB-side log can't show why the UE didn't use the room. The next uplink block, frame 42 (outside this window), carries a 267-byte DRB 2 SDU: inside the reported range.

[Frame 40.2] The Long BSR subheader (LCID 30). Its three-byte body is the BSR arrow above.

[Frame 40.3] `LCID 4`, 986 bytes: RLC `SN=2`, the rest of PDCP SN 2. The RLC page follows the SIP segmentation.

[Frame 40.4] Padding: 341 bytes.

[Frame 846.1] Phase 5 - call 1: the voice bearer arrives. About 22 s later. `LCID 1`, 105 bytes: the reconfiguration that adds DRB 3 for call 1's voice. Its `logicalChannelConfig` gives `LCID 5` priority 2, far above DRB 2 and DRB 1 at 11, and `logicalChannelGroup 1`. A voice frame will now win any grant it competes for.



[Frame 846.2] Padding: 5 bytes close out the 113-byte downlink block.

[Frame 847.1] SFN 738 subframe 8: the busiest uplink block in this window, seven subheaders.

The Short BSR reports LCG 2, index 33: 1326 < BS <= 1552 bytes of IMS signaling still queued. That is the SIP PRACK, which is already starting to go out in this block.

[Frame 847.2] PHR index 20, −3 <= PH < −2 dB. Negative: at this grant size the UE would need more power than its maximum. The headroom has fallen 36 steps since frame 4.

[Frame 847.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 847.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 847.5] `LCID 1, 2 bytes: SRB1 Status PDU, ACK_SN=8, acknowledging the reconfiguration.`

[Frame 847.6] `LCID 1, 9 bytes: RLC SN=10, the RRC Reconfiguration Complete for DRB 3.`

[Frame 847.7] `LCID 2, 19 bytes: SRB2 RLC SN=3, the NAS Activate Dedicated EPS Bearer Context Accept.`

[Frame 847.8] `LCID 4, 2 bytes: DRB 2 Status PDU, ACK_SN=23.`

[Frame 847.9] `LCID 4,` the remaining 488 bytes: one RLC PDU (`SN=26`) holding two whole PDCP PDUs (SN 28 and 29, TCP ACKs) and the first 327 bytes of the next, which carries the PRACK.

Three logical channels, five SDUs, two control elements, no padding. They appear in priority order: SRB1, SRB2, then DRB 2. The PDCP and SIP pages read what is inside.

[Frame 848.1] Downlink: SRB1 Status PDU, `ACK_SN=11.`

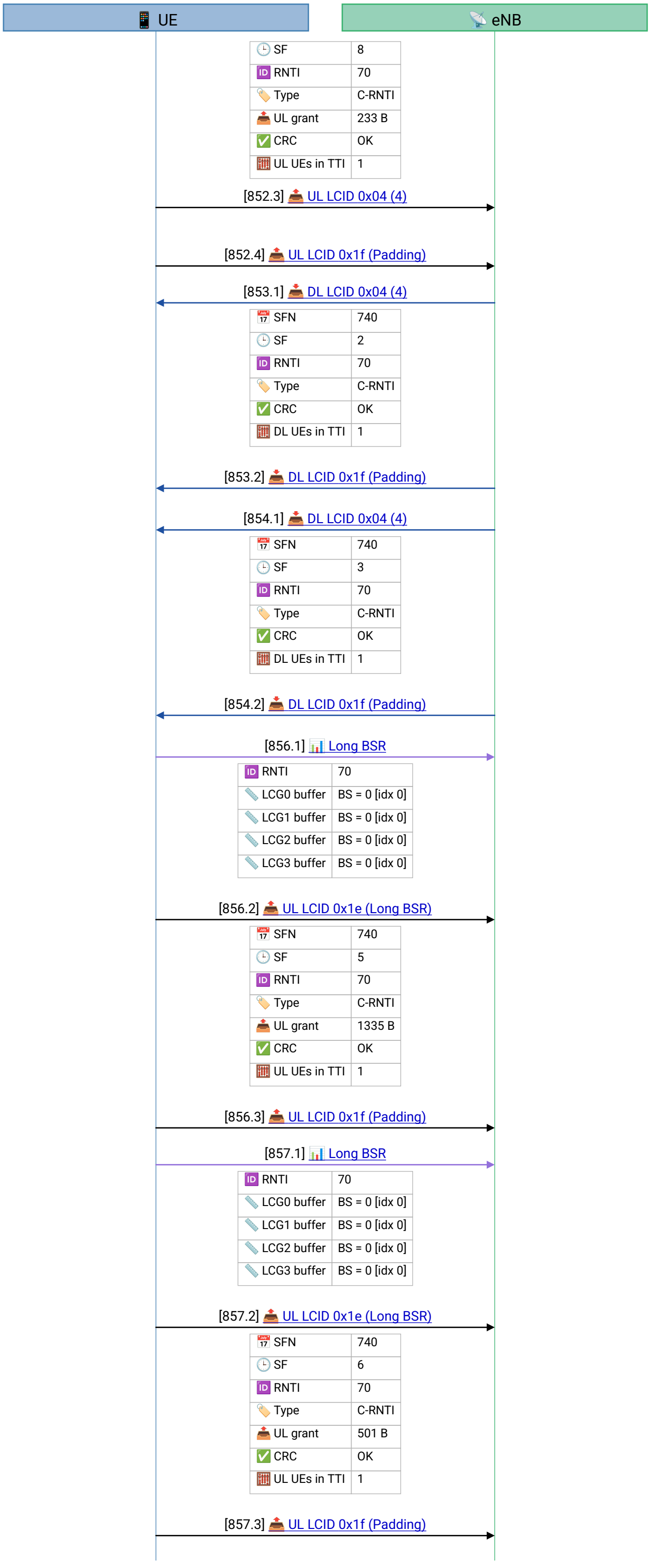
[Frame 848.2] SRB2 Status PDU, `ACK_SN=4.`

[Frame 848.3] Padding: 6 bytes close out the 15-byte downlink block.

[Frame 851] SFN 739 subframe 7: frame 847's report answered with the same pattern as frames 21 and 22. First a 1,335-byte grant, filled by one RLC PDU (`SN=27`) : the rest of the PRACK's first TCP segment and the start of its second.

[Frame 852.1] SFN 739 subframe 8: a 233-byte grant. Again 1,335 + 233 = 1,568 bytes against a reported 1,552 at most. The Long BSR is all zero: a padding BSR.

[Frame 852.2] Subheader `LCID 30,` Long BSR.



[Frame 852.3] LCID 4, 29 bytes: RLC SN=28, the last 27 bytes of the PRACK's second TCP segment. RLC SN 26, 27 and 28 carried it across frames 847, 851 and 852.

[Frame 852.4] Padding: 197 bytes.

[Frame 853.1] Downlink DRB 2 Status PDU, ACK_SN=29 : the eNB has everything up to RLC SN 28.

[Frame 853.2] Padding: 82 bytes close out the 87-byte downlink block.

[Frame 854.1] LCID 4, 160 bytes: one RLC PDU with two TCP ACKs from the P-CSCF.

[Frame 854.2] Padding: 9 bytes close out the 173-byte downlink block.

[Frame 856.1] SFN 740 subframe 5: and again a second pair of grants after the backlog has drained, as in frames 25 and 26. 1,335 bytes, filled with a zero Long BSR and padding.

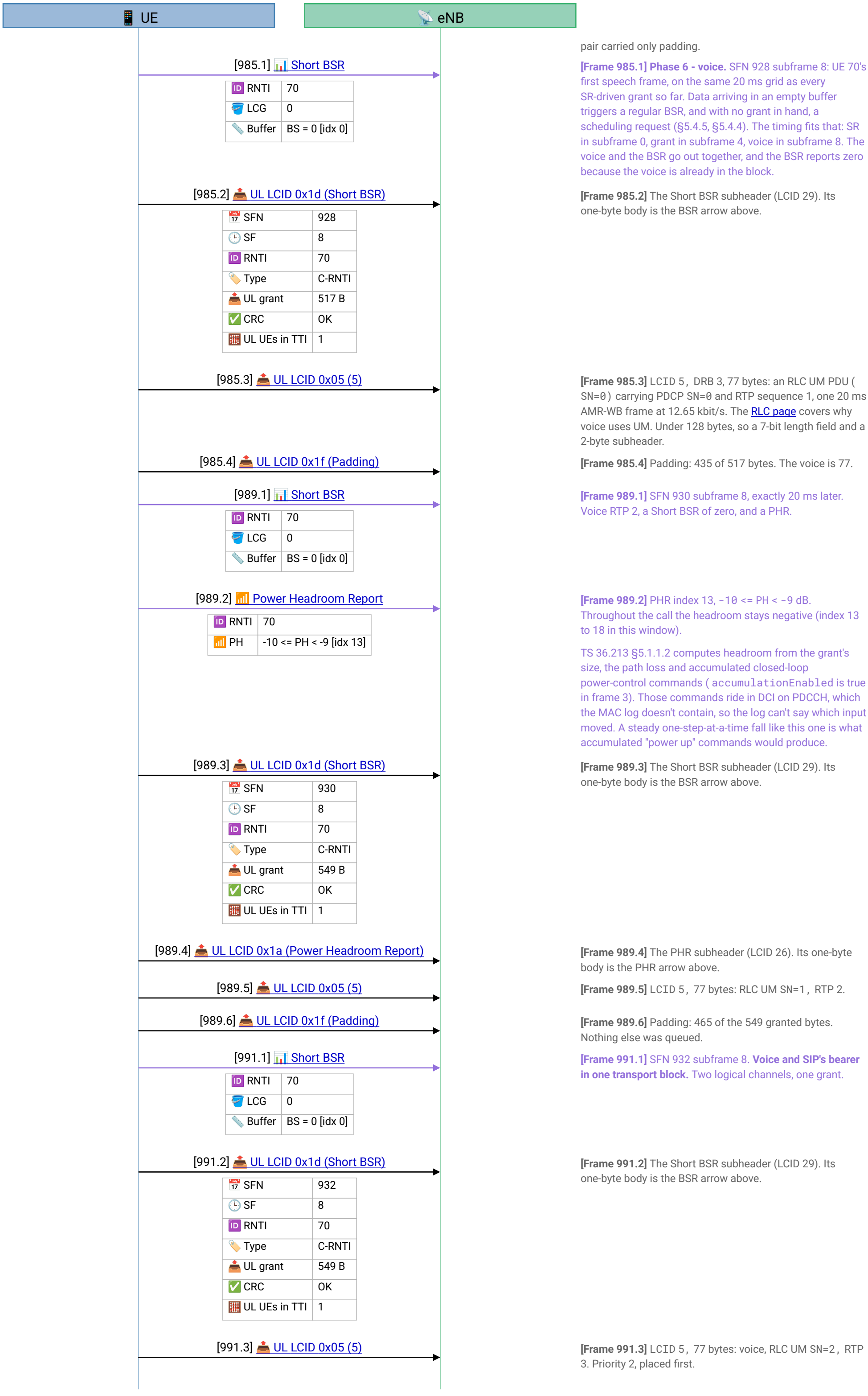
[Frame 856.2] Subheader LCID 30, Long BSR.

[Frame 856.3] Padding: 1,330 bytes.

[Frame 857.1] SFN 740 subframe 6: 501 bytes this time, Long BSR zero.

[Frame 857.2] Subheader LCID 30, Long BSR.

[Frame 857.3] Padding: 496 bytes. Twice in this window a non-zero BSR has drawn two grant pairs, and the second



pair carried only padding.

[Frame 985.1] Phase 6 - voice. SFN 928 subframe 8: UE 70's first speech frame, on the same 20 ms grid as every SR-driven grant so far. Data arriving in an empty buffer triggers a regular BSR, and with no grant in hand, a scheduling request (§5.4.5, §5.4.4). The timing fits that: SR in subframe 0, grant in subframe 4, voice in subframe 8. The voice and the BSR go out together, and the BSR reports zero because the voice is already in the block.

[Frame 985.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 985.3] `LCID 5, DRB 3, 77 bytes: an RLC UM PDU (SN=0)` carrying PDCP SN=0 and RTP sequence 1, one 20 ms AMR-WB frame at 12.65 kbit/s. The RLC page covers why voice uses UM. Under 128 bytes, so a 7-bit length field and a 2-byte subheader.

[Frame 985.4] Padding: 435 of 517 bytes. The voice is 77.

[Frame 989.1] SFN 930 subframe 8, exactly 20 ms later. Voice RTP 2, a Short BSR of zero, and a PHR.

[Frame 989.2] PHR index 13, `-10 <= PH < -9` dB. Throughout the call the headroom stays negative (index 13 to 18 in this window).

TS 36.213 §5.1.1.2 computes headroom from the grant's size, the path loss and accumulated closed-loop power-control commands (`accumulationEnabled` is true in frame 3). Those commands ride in DCI on PDCCH, which the MAC log doesn't contain, so the log can't say which input moved. A steady one-step-at-a-time fall like this one is what accumulated "power up" commands would produce.

[Frame 989.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 989.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 989.5] `LCID 5, 77 bytes: RLC UM SN=1, RTP 2.`

[Frame 989.6] Padding: 465 of the 549 granted bytes. Nothing else was queued.

[Frame 991.1] SFN 932 subframe 8. **Voice and SIP's bearer in one transport block.** Two logical channels, one grant.

[Frame 991.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 991.3] `LCID 5, 77 bytes: voice, RLC UM SN=2, RTP 3.` Priority 2, placed first.



[Frame 991.4] LCID 4, 2 bytes: a DRB 2 Status PDU, ACK_SN=30, acknowledging the eNB's downlink DRB 2 traffic. The IMS signaling bearer's feedback rides in the voice frame's grant instead of waiting for one of its own. That is TTI-level multiplexing: everything ready for this one 1 ms transmission time interval (TTI) shares the block, in priority order.

[Frame 991.5] Padding: 463 bytes.

[Frame 994.1] Short BSR: LCG 0, BS = 0 (index 0). Nothing left queued after this block.

[Frame 994.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 994.3] LCID 5, DRB 3 (call-1 voice), 77 bytes: an RLC UM PDU, SN=3.

[Frame 994.4] Padding: 451 of the 533 granted bytes. Nothing else was queued.

[Frame 996.1] Short BSR: LCG 0, BS = 0 (index 0). Nothing left queued after this block.

[Frame 996.2] PHR index 15, −8 <= PH < −7 dB. 60 ms since the last: the first 20 ms grant after the 50 ms timer ran out.

[Frame 996.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 996.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 996.5] LCID 5, DRB 3 (call-1 voice), 77 bytes: an RLC UM PDU, SN=4.

[Frame 996.6] Padding: 433 of the 517 granted bytes. Nothing else was queued.

[Frame 998.1] Short BSR: LCG 0, BS = 0 (index 0). Nothing left queued after this block.

[Frame 998.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 998.3] LCID 5, DRB 3 (call-1 voice), 77 bytes: an RLC UM PDU, SN=5.

[Frame 998.4] Padding: 435 of the 517 granted bytes.



Nothing else was queued.

[Frame 1000.1] Short BSR: LCG 0, BS = 0 (index 0). Nothing left queued after this block.

[Frame 1000.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 1000.3] LCID 5, DRB 3 (call-1 voice), 77 bytes: an RLC UM PDU, SN=6.

[Frame 1000.4] Padding: 435 of the 517 granted bytes. Nothing else was queued.

[Frame 1003.1] Downlink: the first voice from UE 71, relayed through the media relay. LCID 5, 105 bytes, RLC UM SN=0, RTP 0, AMR-WB at 23.85 kbit/s. Downlink voice lands in subframe 5 of odd-numbered frames, every 20 ms.

[Frame 1003.2] Padding: 5 bytes. Downlink voice blocks pad 5 bytes; uplink voice blocks pad over 400.

[Frame 1004.1] SFN 942 subframe 8. The talk spurt ends: this is AMR-WB SID_FIRST, the start of silence suppression (TS 26.193). The SDU shrinks; the grant doesn't.

[Frame 1004.2] PHR index 16, −7 <= PH < −6 dB.

[Frame 1004.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 1004.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

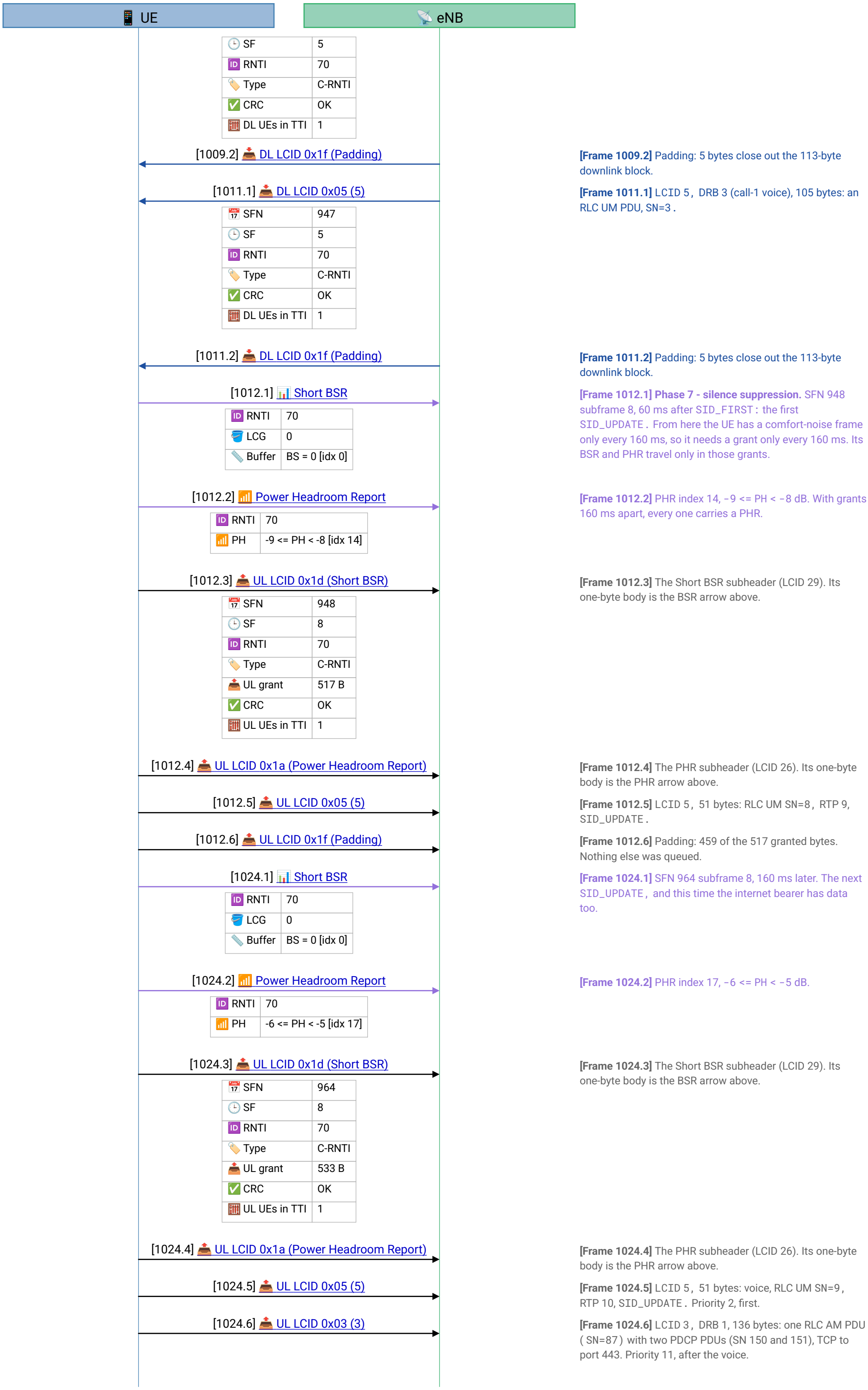
[Frame 1004.5] LCID 5, 51 bytes: RLC UM SN=7, RTP 8, a SID frame (AMR-WB frame type 9). 26 bytes smaller than a speech frame.

[Frame 1004.6] Padding: 475 of 533 bytes.

[Frame 1007.1] LCID 5, DRB 3 (call-1 voice), 105 bytes: an RLC UM PDU, SN=1.

[Frame 1007.2] Padding: 5 bytes close out the 113-byte downlink block.

[Frame 1009.1] LCID 5, DRB 3 (call-1 voice), 105 bytes: an RLC UM PDU, SN=2.



[Frame 1009.2] Padding: 5 bytes close out the 113-byte downlink block.

[Frame 1011.1] `LCID 5, DRB 3 (call-1 voice), 105 bytes: an RLC UM PDU, SN=3.`

[Frame 1011.2] Padding: 5 bytes close out the 113-byte downlink block.

[Frame 1012.1] Phase 7 - silence suppression. SFN 948 subframe 8, 60 ms after `SID_FIRST`: the first `SID_UPDATE`. From here the UE has a comfort-noise frame only every 160 ms, so it needs a grant only every 160 ms. Its BSR and PHR travel only in those grants.

[Frame 1012.2] PHR index 14, −9 <= PH < −8 dB. With grants 160 ms apart, every one carries a PHR.

[Frame 1012.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 1012.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 1012.5] `LCID 5, 51 bytes: RLC UM SN=8, RTP 9, SID_UPDATE.`

[Frame 1012.6] Padding: 459 of the 517 granted bytes. Nothing else was queued.

[Frame 1024.1] SFN 964 subframe 8, 160 ms later. The next `SID_UPDATE`, and this time the internet bearer has data too.

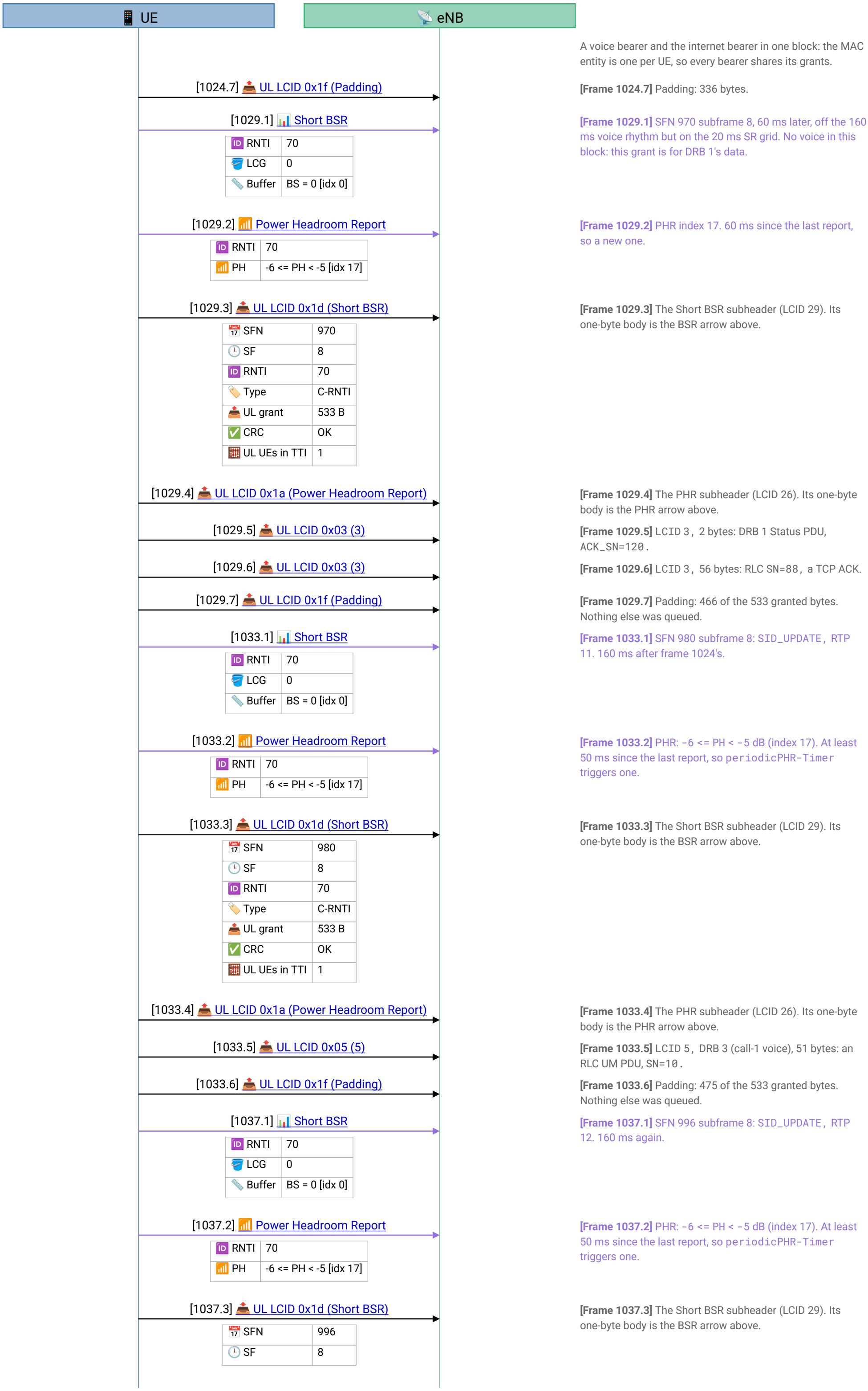
[Frame 1024.2] PHR index 17, −6 <= PH < −5 dB.

[Frame 1024.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 1024.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 1024.5] `LCID 5, 51 bytes: voice, RLC UM SN=9, RTP 10, SID_UPDATE. Priority 2, first.`

[Frame 1024.6] `LCID 3, DRB 1, 136 bytes: one RLC AM PDU (SN=87) with two PDCP PDUs (SN 150 and 151), TCP to port 443. Priority 11, after the voice.`



A voice bearer and the internet bearer in one block: the MAC entity is one per UE, so every bearer shares its grants.

[Frame 1024.7] Padding: 336 bytes.

[Frame 1029.1] SFN 970 subframe 8, 60 ms later, off the 160 ms voice rhythm but on the 20 ms SR grid. No voice in this block: this grant is for DRB 1's data.

[Frame 1029.2] PHR index 17. 60 ms since the last report, so a new one.

[Frame 1029.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 1029.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 1029.5] `LCID 3, 2 bytes: DRB 1 Status PDU, ACK_SN=120.`

[Frame 1029.6] `LCID 3, 56 bytes: RLC SN=88,` a TCP ACK.

[Frame 1029.7] Padding: 466 of the 533 granted bytes. Nothing else was queued.

[Frame 1033.1] SFN 980 subframe 8: `SID_UPDATE, RTP` 11. 160 ms after frame 1024's.

[Frame 1033.2] PHR: `-6 <= PH < -5` dB (index 17). At least 50 ms since the last report, so `periodicPHR-Timer` triggers one.

[Frame 1033.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 1033.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

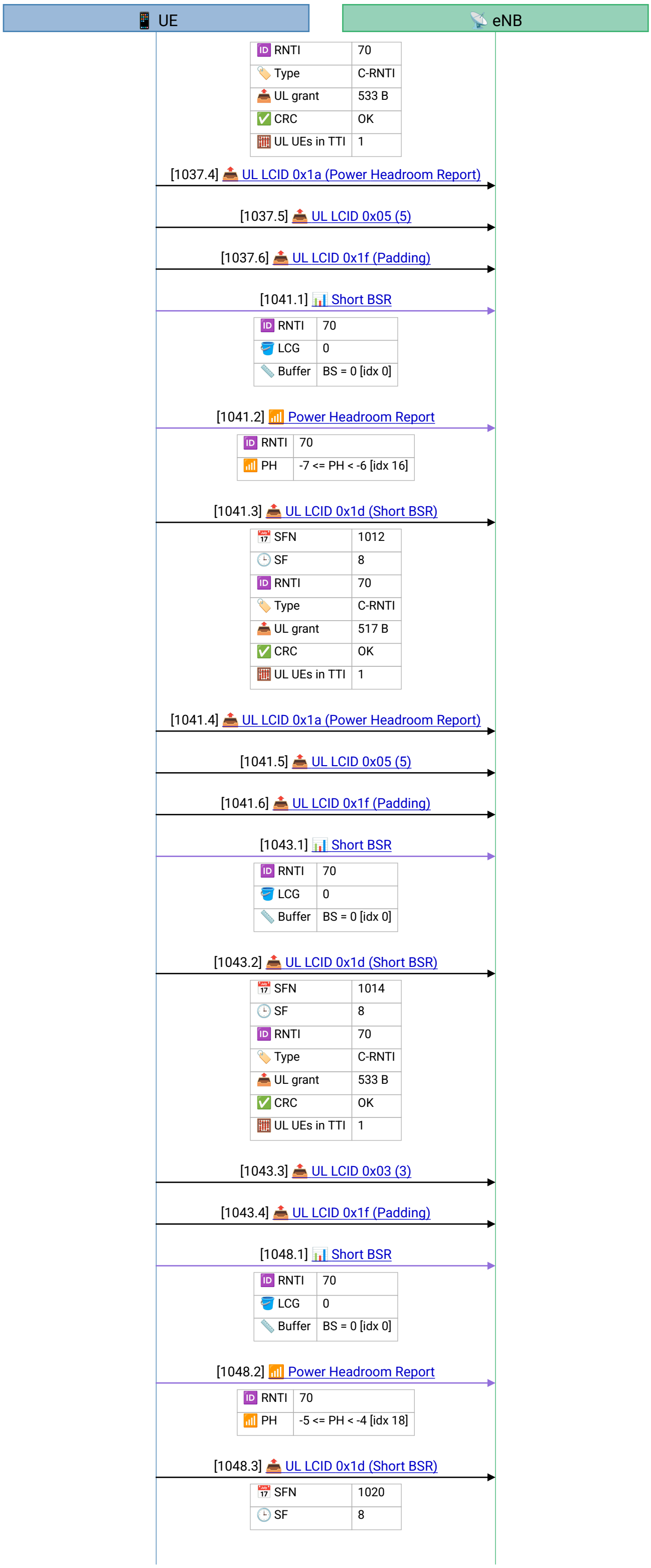
[Frame 1033.5] `LCID 5, DRB 3 (call-1 voice), 51 bytes: an RLC UM PDU, SN=10.`

[Frame 1033.6] Padding: 475 of the 533 granted bytes. Nothing else was queued.

[Frame 1037.1] SFN 996 subframe 8: `SID_UPDATE, RTP` 12. 160 ms again.

[Frame 1037.2] PHR: `-6 <= PH < -5` dB (index 17). At least 50 ms since the last report, so `periodicPHR-Timer` triggers one.

[Frame 1037.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.



[Frame 1037.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 1037.5] `LCID 5, DRB 3` (call-1 voice), 51 bytes: an RLC UM PDU, `SN=11`.

[Frame 1037.6] Padding: 475 of the 533 granted bytes. Nothing else was queued.

[Frame 1041.1] SFN 1012 subframe 8: `SID_UPDATE, RTP 13`. Each `SID_UPDATE` costs one grant of about 520 bytes, to carry 51.

[Frame 1041.2] PHR: `-7 <= PH < -6` dB (index 16). At least 50 ms since the last report, so `periodicPHR-Timer` triggers one.

[Frame 1041.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

[Frame 1041.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 1041.5] `LCID 5, DRB 3` (call-1 voice), 51 bytes: an RLC UM PDU, `SN=12`.

[Frame 1041.6] Padding: 459 of the 517 granted bytes. Nothing else was queued.

[Frame 1043.1] SFN 1014 subframe 8, 20 ms after frame 1041: DRB 1 data again. **No PHR:** only 20 ms since the last report, short of the 50 ms timer. Every PHR gap in this window is at least 50 ms.

[Frame 1043.2] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.

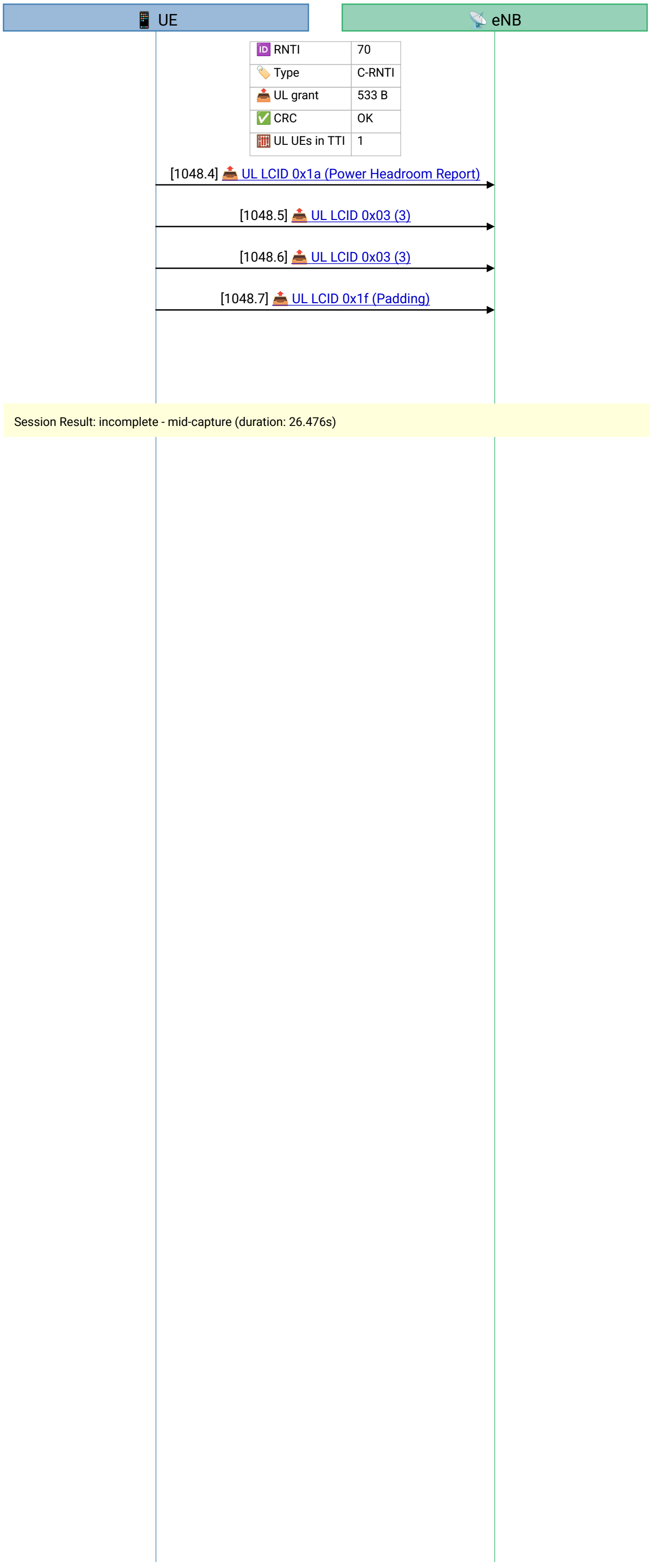
[Frame 1043.3] `LCID 3, 136` bytes: RLC `SN=89, two` more PDCP PDUs (SN 153 and 154), TCP to port 443.

[Frame 1043.4] Padding: 391 of the 533 granted bytes. Nothing else was queued.

[Frame 1048.1] SFN 1020 subframe 8. In all 38 of UE 70's uplink blocks during call 1 (frames 985-1140), every one sits on the 20 ms grid and carries a Short BSR of zero. UE 70 never builds a backlog during the call: each frame fits in the grant that follows it.

[Frame 1048.2] PHR index 18, −5 <= PH < −4 dB, 80 ms after the last.

[Frame 1048.3] The Short BSR subheader (LCID 29). Its one-byte body is the BSR arrow above.



[Frame 1048.4] The PHR subheader (LCID 26). Its one-byte body is the PHR arrow above.

[Frame 1048.5] `LCID 3, 2 bytes: DRB 1 Status PDU, ACK_SN=123.`

[Frame 1048.6] `LCID 3, 131 bytes: RLC SN=90` with three 40-byte TCP packets (PDCP SN 155-157).

[Frame 1048.7] Padding: 390 bytes. Across call 1, UE 70's 38 uplink blocks hold 20,030 bytes, of which 17,333 are padding. Its 45 downlink blocks hold 3,083 bytes, 262 of them padding. The eNB sizes downlink blocks from data it can see; it sizes uplink grants before it knows what the UE will send.

Session Result: incomplete - mid-capture (duration: 26.476s)