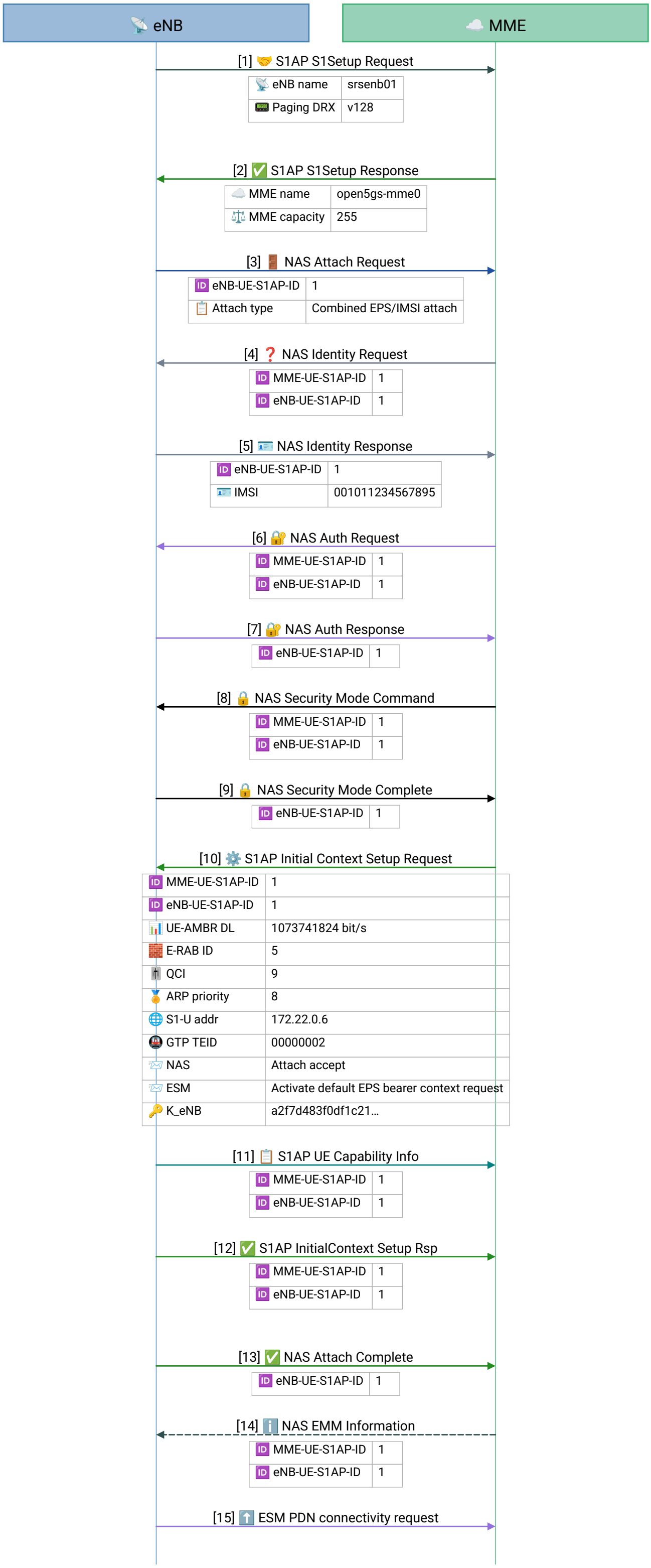
lte-s1ap-attach-volte.annotated



[Frame 1] Phase 1 - The eNB joins the core. S1 Setup Request, 4.5 s before any phone appears. The eNB `srsenb01` introduces itself: macro eNB ID 411 (`0x0019b`), PLMN 001/01, tracking area code 1. S1AP runs over SCTP in a real network; this srsRAN log stores the bare S1AP messages, so there is no IP or SCTP layer.

[Frame 2] S1 Setup Response from `open5gs-mme0`, relative capacity 255. The S1 interface is up and the eNB can now carry UE traffic to this MME.

[Frame 3] Phase 2 - UE 70's attach. Initial UE Message, 0.7 ms after MAC frame 4 delivered the RRC Connection Setup Complete. The eNB assigns this UE `eNB-UE-S1AP-ID` 1 and passes the NAS Attach Request (combined EPS/IMSI attach) to the MME untouched.

[Frame 4] Downlink NAS Transport: Identity Request. The MME now assigns its own handle, `MME-UE-S1AP-ID` 1. From here every message for this UE carries both IDs, one per end of the S1 link.

[Frame 5] Uplink NAS Transport: Identity Response, IMSI `001011234567895` (MAC frame 7).

[Frame 6] Authentication Request, relayed down (MAC frame 9).

[Frame 7] Authentication Response (MAC frame 11).

[Frame 8] NAS Security Mode Command: EEA0 / EIA2 (MAC frame 13).

[Frame 9] NAS Security Mode Complete (MAC frame 14).

[Frame 10] The UE context arrives. Initial Context Setup Request: the MME hands the eNB everything it needs to serve this UE:

- `K_eNB`, the 256-bit key the eNB derives the radio (AS) keys from,
- the UE's security capabilities (EEA1-3 and EIA1-3 supported; the null cipher was the network's choice),
- the default E-RAB: ID 5, `QCI 9`, ARP priority 8, and the S-GW's tunnel endpoint (172.22.0.6, TEID 0x2),
- a UE aggregate maximum bit rate of 1 Gbit/s downlink,
- the NAS Attach Accept + Activate Default EPS Bearer to deliver.

0.75 ms later the eNB starts AS security on the radio (MAC frame 16). The K_eNB in this message is what makes that possible.

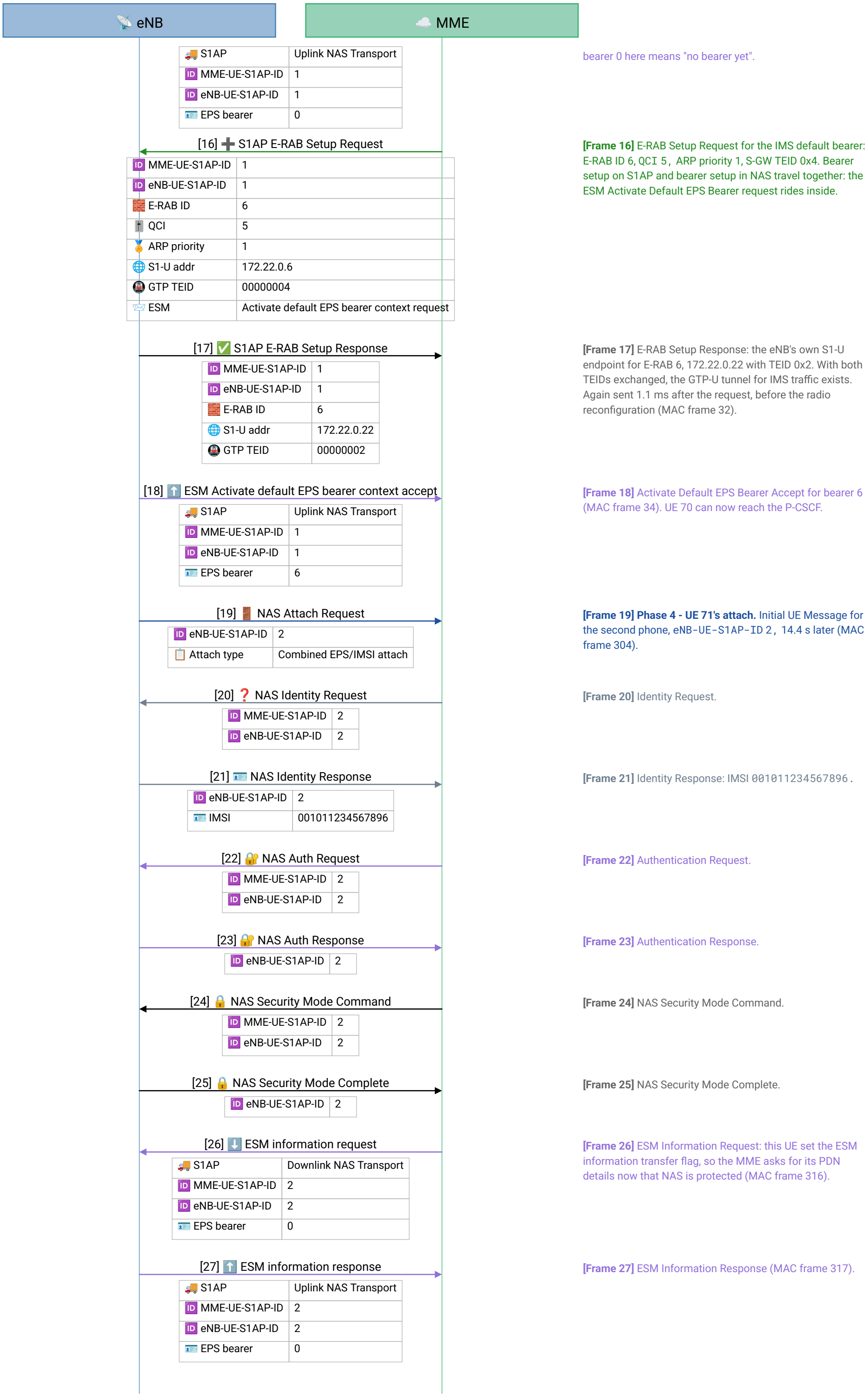
[Frame 11] UE Capability Info Indication: the eNB forwards the radio capabilities it fetched in MAC frames 19-22, so the MME can store them and hand them to the next eNB.

[Frame 12] Initial Context Setup Response. srsRAN answers here, 2.7 ms *before* it sends the RRC Connection Reconfiguration carrying the Attach Accept (MAC frame 24). TS 23.401's attach flow puts this response after the UE's Reconfiguration Complete. The MME accepts it, and the attach proceeds.

[Frame 13] Uplink NAS Transport: Attach Complete + Activate Default EPS Bearer Accept (MAC frame 27). UE 70 is registered.

[Frame 14] EMM Information: network name and time (MAC frame 29).

[Frame 15] Phase 3 - UE 70's IMS PDN. PDN Connectivity Request for the `ims` APN, relayed up (MAC frame 30). EPS



bearer 0 here means "no bearer yet".

[Frame 16] E-RAB Setup Request for the IMS default bearer: E-RAB ID 6, `QCI 5`, ARP priority 1, S-GW TEID 0x4. Bearer setup on S1AP and bearer setup in NAS travel together: the ESM Activate Default EPS Bearer request rides inside.

[Frame 17] E-RAB Setup Response: the eNB's own S1-U endpoint for E-RAB 6, 172.22.0.22 with TEID 0x2. With both TEIDs exchanged, the GTP-U tunnel for IMS traffic exists. Again sent 1.1 ms after the request, before the radio reconfiguration (MAC frame 32).

[Frame 18] Activate Default EPS Bearer Accept for bearer 6 (MAC frame 34). UE 70 can now reach the P-CSCF.

[Frame 19] Phase 4 - UE 71's attach. Initial UE Message for the second phone, `eNB-UE-S1AP-ID 2`, 14.4 s later (MAC frame 304).

[Frame 20] Identity Request.

[Frame 21] Identity Response: IMSI `001011234567896`.

[Frame 22] Authentication Request.

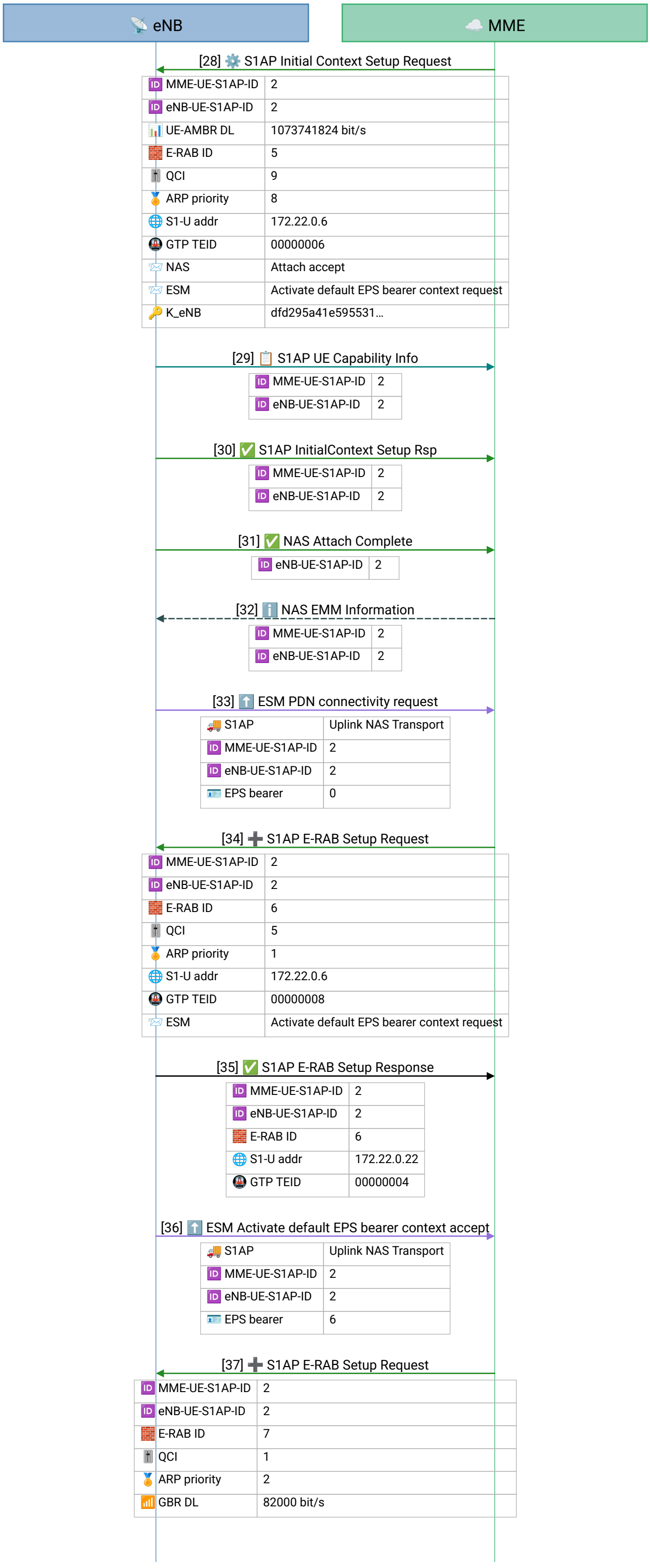
[Frame 23] Authentication Response.

[Frame 24] NAS Security Mode Command.

[Frame 25] NAS Security Mode Complete.

[Frame 26] ESM Information Request: this UE set the ESM information transfer flag, so the MME asks for its PDN details now that NAS is protected (MAC frame 316).

[Frame 27] ESM Information Response (MAC frame 317).



[Frame 28] Initial Context Setup Request for UE 71: the same shape as frame 10, with its own K_eNB and S-GW TEID 0x6.

[Frame 29] UE Capability Info Indication (from MAC frame 323).

[Frame 30] Initial Context Setup Response, again ahead of the radio reconfiguration (MAC frame 325).

[Frame 31] Attach Complete. UE 71 is registered.

[Frame 32] EMM Information.

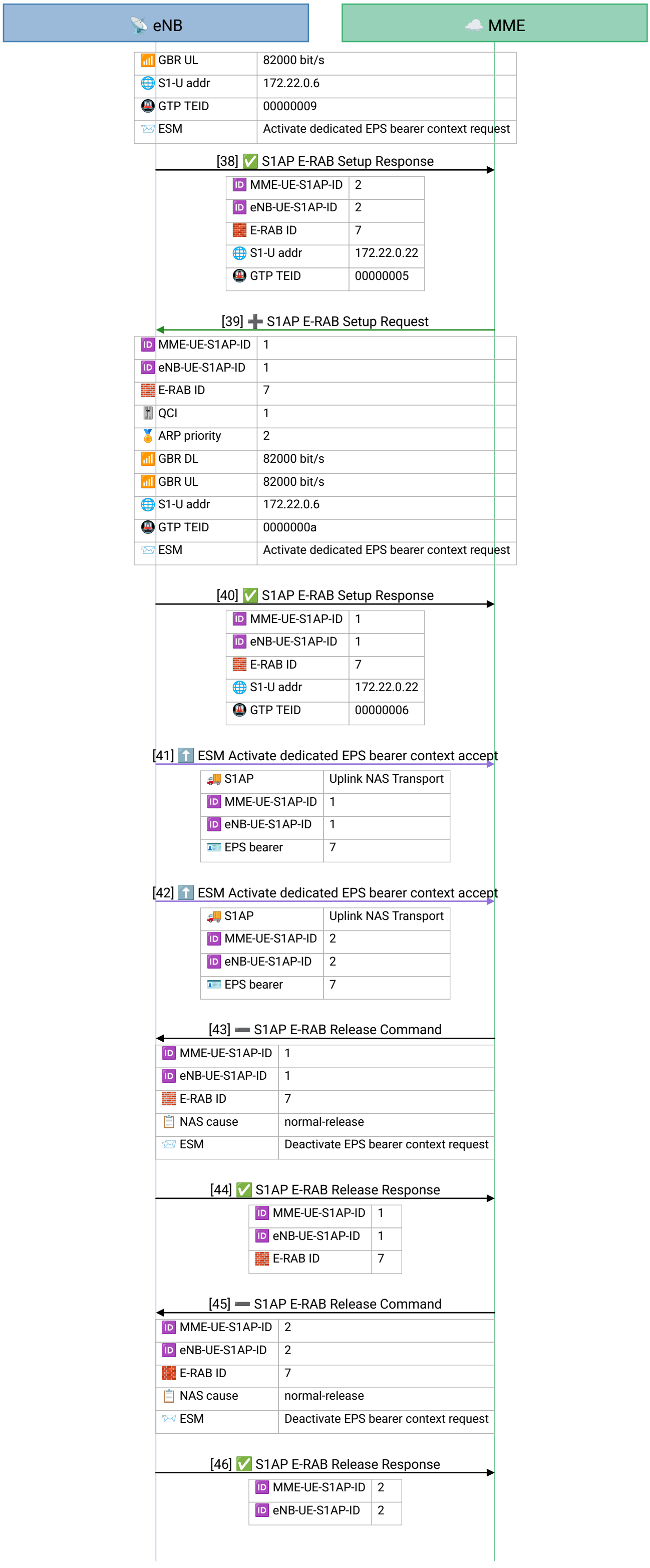
[Frame 33] PDN Connectivity Request for `ims` (MAC frame 511).

[Frame 34] E-RAB Setup Request: E-RAB 6, QCI 5, S-GW TEID 0x8.

[Frame 35] E-RAB Setup Response: eNB TEID 0x4.

[Frame 36] Activate Default EPS Bearer Accept. Both phones now have internet (E-RAB 5) and IMS (E-RAB 6). For the next 6.6 s, until the first call, everything (UE 71's IMS registration included) runs on the user plane, invisible to S1AP.

[Frame 37] Phase 5 - Call 1 (UE 70 calls UE 71). E-RAB Setup Request for the voice bearer, 7 ms after UE 71 sent its SIP 183 (MAC frame 839). E-RAB ID 7, `QCI 1`, ARP priority 2, guaranteed and maximum bit rate 82,000 bit/s each way. The callee's bearer comes first, as in every call in this capture: the 183 with the callee's SDP answer is what triggers it. The UE sees 80 kbps in its NAS QoS, because the NAS bit-rate field is coarser than S1AP's.



[Frame 38] E-RAB Setup Response, 0.27 ms after the request. The RRC Reconfiguration that builds DRB 3 has not left the eNB yet (MAC frame 844, 1 ms later). TS 23.401's dedicated bearer flow puts this response after the UE's Reconfiguration Complete; srsRAN reports success as soon as it has allocated the bearer.

[Frame 39] The caller's voice bearer, 7 ms later: E-RAB 7 for UE 70, QCI 1, 82 kbit/s, S-GW TEID 0xa (MAC frame 846).

[Frame 40] E-RAB Setup Response for UE 70, eNB TEID 0x6.

[Frame 41] UE 70's Activate Dedicated EPS Bearer Accept (MAC frame 847), 34 ms after the request: the round trip over the radio.

[Frame 42] UE 71's accept (MAC frame 849). Both voice bearers exist; on the user plane, PRACK and UPDATE now clear the SIP preconditions and the phone rings.

[Frame 43] Call 1 ends. E-RAB Release Command for UE 70's E-RAB 7, cause nas / normal release, with the ESM Deactivate EPS Bearer request inside. It comes 8.7 ms after UE 71's BYE (MAC frame 1143), 6.4 s after the bearer was created.

[Frame 44] E-RAB Release Response, again before the radio side (MAC frame 1146).

[Frame 45] Release Command for UE 71's E-RAB 7.

[Frame 46] E-RAB Release Response.

eNB | MME

E-RAB ID	7

[47] ESM Deactivate EPS bearer context accept

S1AP	Uplink NAS Transport
MME-UE-S1AP-ID	2
eNB-UE-S1AP-ID	2
EPS bearer	7

[Frame 47] UE 71's Deactivate EPS Bearer Accept (MAC frame 1150).

[48] ESM Deactivate EPS bearer context accept

S1AP	Uplink NAS Transport
MME-UE-S1AP-ID	1
eNB-UE-S1AP-ID	1
EPS bearer	7

[Frame 48] UE 70's Deactivate EPS Bearer Accept (MAC frame 1152). Call 1 is over on the core side too.

[49] S1AP E-RAB Setup Request

MME-UE-S1AP-ID	1
eNB-UE-S1AP-ID	1
E-RAB ID	8
QCI	1
ARP priority	2
GBR DL	82000 bit/s
GBR UL	82000 bit/s
S1-U addr	172.22.0.6
GTP TEID	0000000d
ESM	Activate dedicated EPS bearer context request

[Frame 49] Call 2 (UE 71 calls UE 70). The roles swap, and so does the order: the callee, UE 70, gets its bearer first. Note the ID: E-RAB **8,** not 7. The MME moves on to the next EPS bearer identity for each call instead of reusing the one just released. S-GW TEID 0xd.

[50] S1AP E-RAB Setup Response

MME-UE-S1AP-ID	1
eNB-UE-S1AP-ID	1
E-RAB ID	8
S1-U addr	172.22.0.22
GTP TEID	00000007

[Frame 50] E-RAB Setup Response, 0.26 ms later.

[51] S1AP E-RAB Setup Request

MME-UE-S1AP-ID	2
eNB-UE-S1AP-ID	2
E-RAB ID	8
QCI	1
ARP priority	2
GBR DL	82000 bit/s
GBR UL	82000 bit/s
S1-U addr	172.22.0.6
GTP TEID	0000000e
ESM	Activate dedicated EPS bearer context request

[Frame 51] UE 71's E-RAB 8, 6.4 ms later.

[52] S1AP E-RAB Setup Response

MME-UE-S1AP-ID	2
eNB-UE-S1AP-ID	2
E-RAB ID	8
S1-U addr	172.22.0.22
GTP TEID	00000008

[Frame 52] E-RAB Setup Response.

[53] ESM Activate dedicated EPS bearer context accept

S1AP	Uplink NAS Transport
MME-UE-S1AP-ID	1
eNB-UE-S1AP-ID	1
EPS bearer	8

[Frame 53] UE 70 accepts bearer 8.

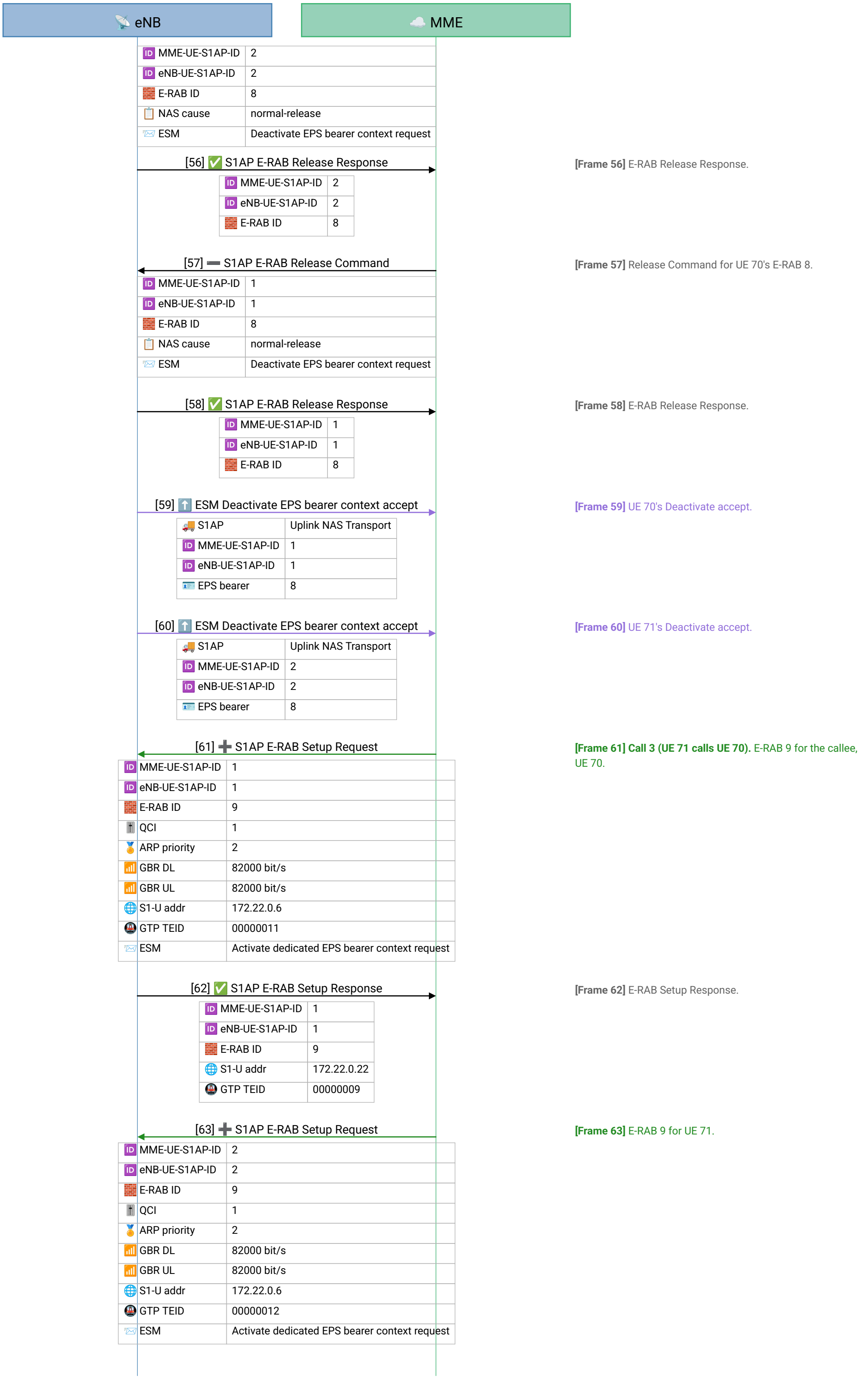
[54] ESM Activate dedicated EPS bearer context accept

S1AP	Uplink NAS Transport
MME-UE-S1AP-ID	2
eNB-UE-S1AP-ID	2
EPS bearer	8

[Frame 54] UE 71 accepts bearer 8.

[55] S1AP E-RAB Release Command

[Frame 55] Call 2 ends after 6.5 s: Release Command for UE 71's E-RAB 8.



[Frame 56] E-RAB Release Response.

[Frame 57] Release Command for UE 70's E-RAB 8.

[Frame 58] E-RAB Release Response.

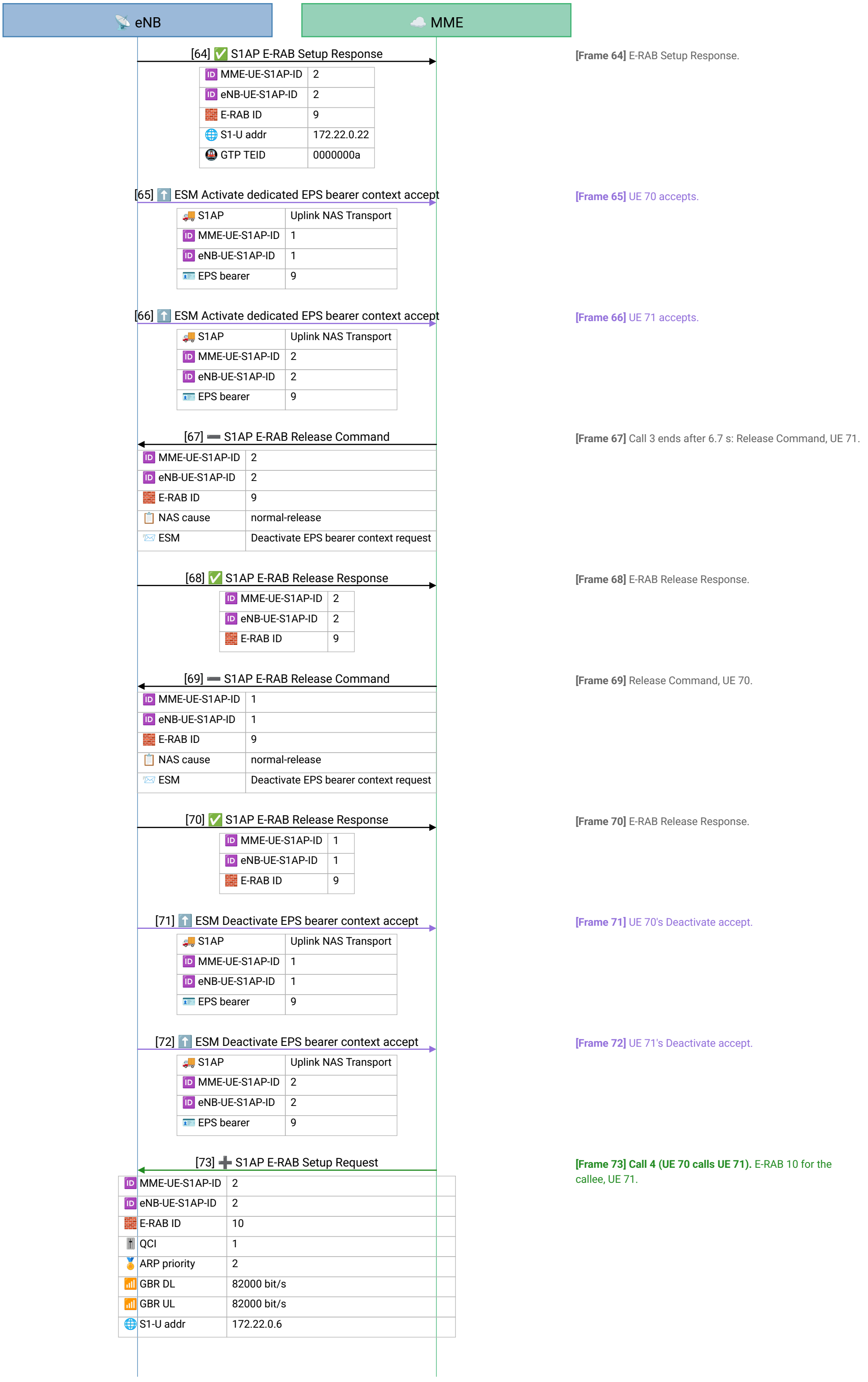
[Frame 59] UE 70's Deactivate accept.

[Frame 60] UE 71's Deactivate accept.

[Frame 61] Call 3 (UE 71 calls UE 70). E-RAB 9 for the callee, UE 70.

[Frame 62] E-RAB Setup Response.

[Frame 63] E-RAB 9 for UE 71.



[Frame 64] E-RAB Setup Response.

[Frame 65] UE 70 accepts.

[Frame 66] UE 71 accepts.

[Frame 67] Call 3 ends after 6.7 s: Release Command, UE 71.

[Frame 68] E-RAB Release Response.

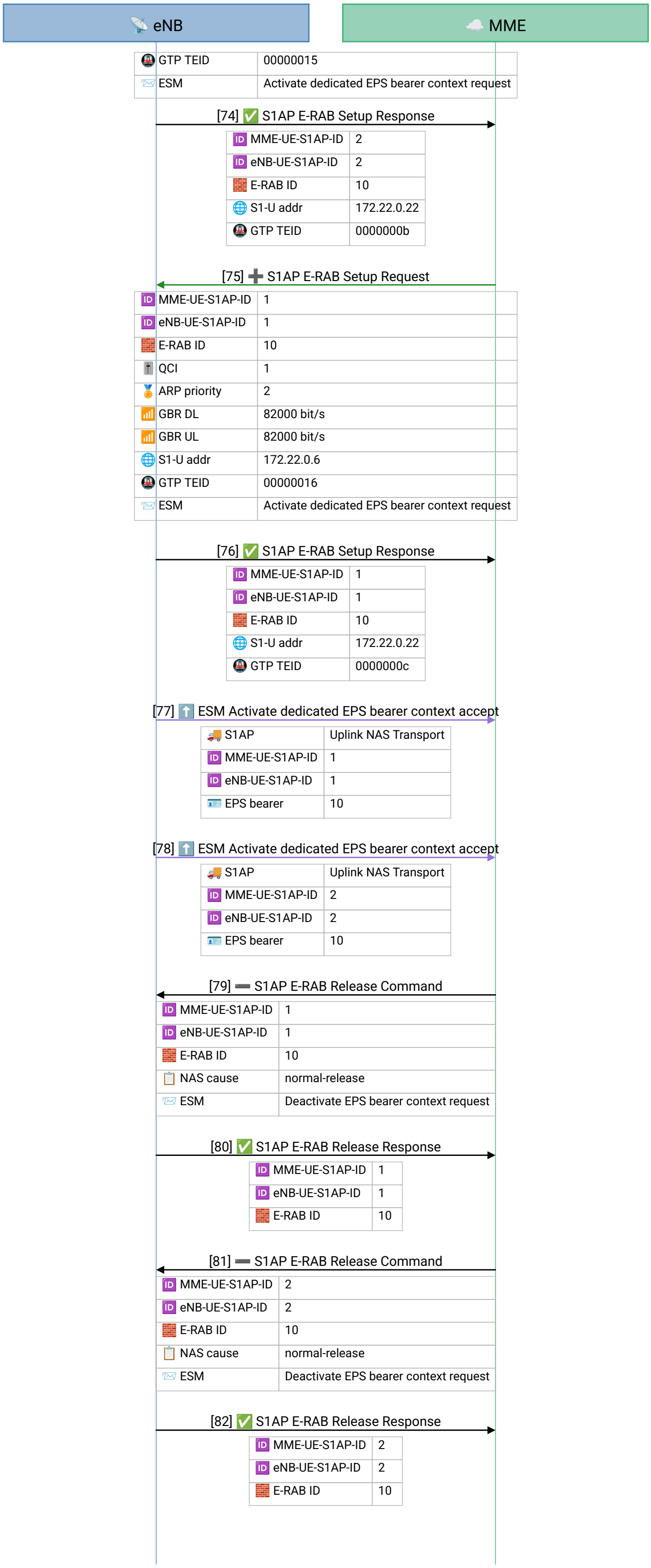
[Frame 69] Release Command, UE 70.

[Frame 70] E-RAB Release Response.

[Frame 71] UE 70's Deactivate accept.

[Frame 72] UE 71's Deactivate accept.

[Frame 73] Call 4 (UE 70 calls UE 71). E-RAB 10 for the callee, UE 71.



[Frame 74] E-RAB Setup Response.

[Frame 75] E-RAB 10 for UE 70.

[Frame 76] E-RAB Setup Response.

[Frame 77] UE 70 accepts.

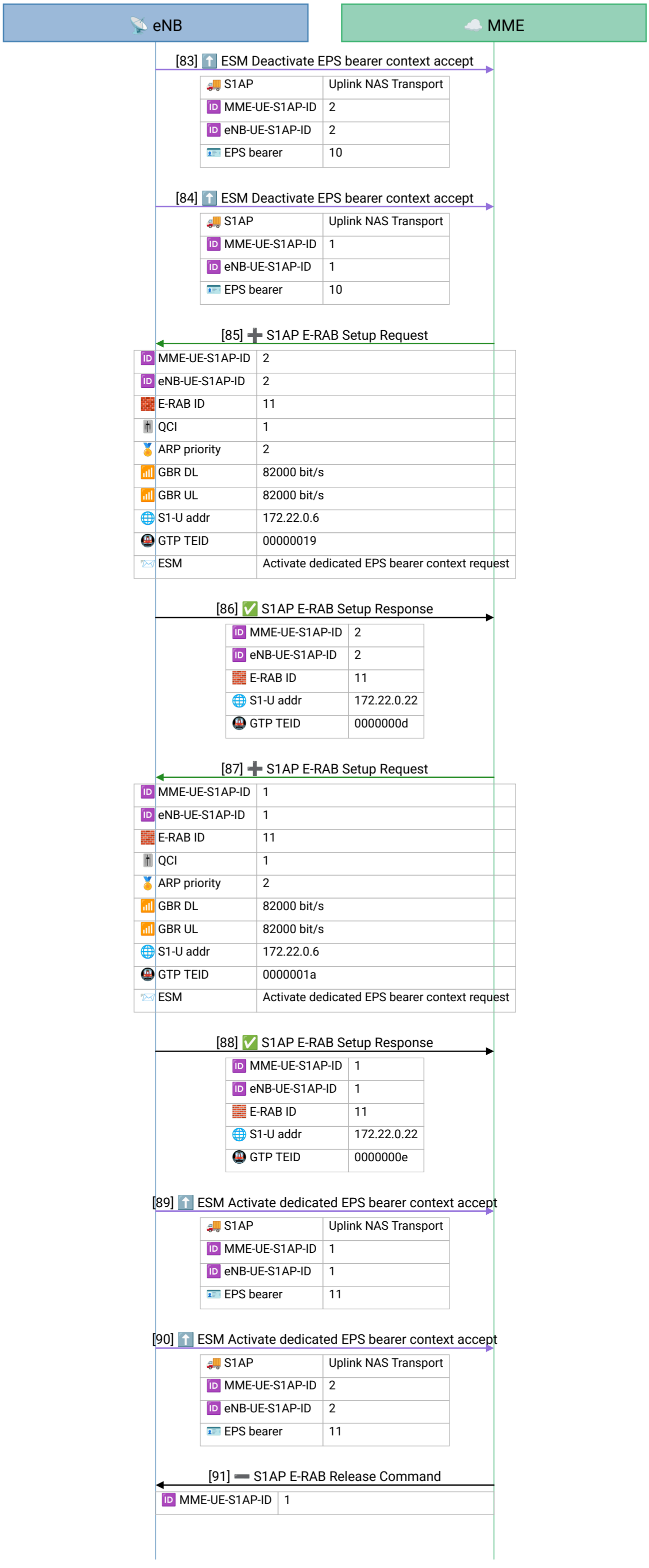
[Frame 78] UE 71 accepts.

[Frame 79] Call 4 ends after 4.7 s, the shortest call: Release Command, UE 70.

[Frame 80] E-RAB Release Response.

[Frame 81] Release Command, UE 71.

[Frame 82] E-RAB Release Response.



[Frame 83] UE 71's Deactivate accept.

[Frame 84] UE 70's Deactivate accept.

[Frame 85] Call 5 (UE 70 calls UE 71). E-RAB 11 for the callee, UE 71.

[Frame 86] E-RAB Setup Response.

[Frame 87] E-RAB 11 for UE 70.

[Frame 88] E-RAB Setup Response.

[Frame 89] UE 70 accepts.

[Frame 90] UE 71 accepts.

[Frame 91] Call 5 ends after 11.7 s, the longest call: Release Command, UE 70.

eNB | MME

eNB-UE-S1AP-ID	1
E-RAB ID	11
NAS cause	normal-release
ESM	Deactivate EPS bearer context request

[92] S1AP E-RAB Release Response

MME-UE-S1AP-ID	1
eNB-UE-S1AP-ID	1
E-RAB ID	11

[Frame 92] E-RAB Release Response.

[93] S1AP E-RAB Release Command

MME-UE-S1AP-ID	2
eNB-UE-S1AP-ID	2
E-RAB ID	11
NAS cause	normal-release
ESM	Deactivate EPS bearer context request

[Frame 93] Release Command, UE 71.

[94] S1AP E-RAB Release Response

MME-UE-S1AP-ID	2
eNB-UE-S1AP-ID	2
E-RAB ID	11

[Frame 94] E-RAB Release Response.

[95] ESM Deactivate EPS bearer context accept

S1AP	Uplink NAS Transport
MME-UE-S1AP-ID	2
eNB-UE-S1AP-ID	2
EPS bearer	11

[Frame 95] UE 71's Deactivate accept.

[96] ESM Deactivate EPS bearer context accept

S1AP	Uplink NAS Transport
MME-UE-S1AP-ID	1
eNB-UE-S1AP-ID	1
EPS bearer	11

[Frame 96] UE 70's Deactivate accept.

[97] S1AP E-RAB Setup Request

MME-UE-S1AP-ID	1
eNB-UE-S1AP-ID	1
E-RAB ID	12
QCI	1
ARP priority	2
GBR DL	82000 bit/s
GBR UL	82000 bit/s
S1-U addr	172.22.0.6
GTP TEID	0000001d
ESM	Activate dedicated EPS bearer context request

[Frame 97] Call 6 (UE 71 calls UE 70). E-RAB 12 for the callee, UE 70.

[98] S1AP E-RAB Setup Response

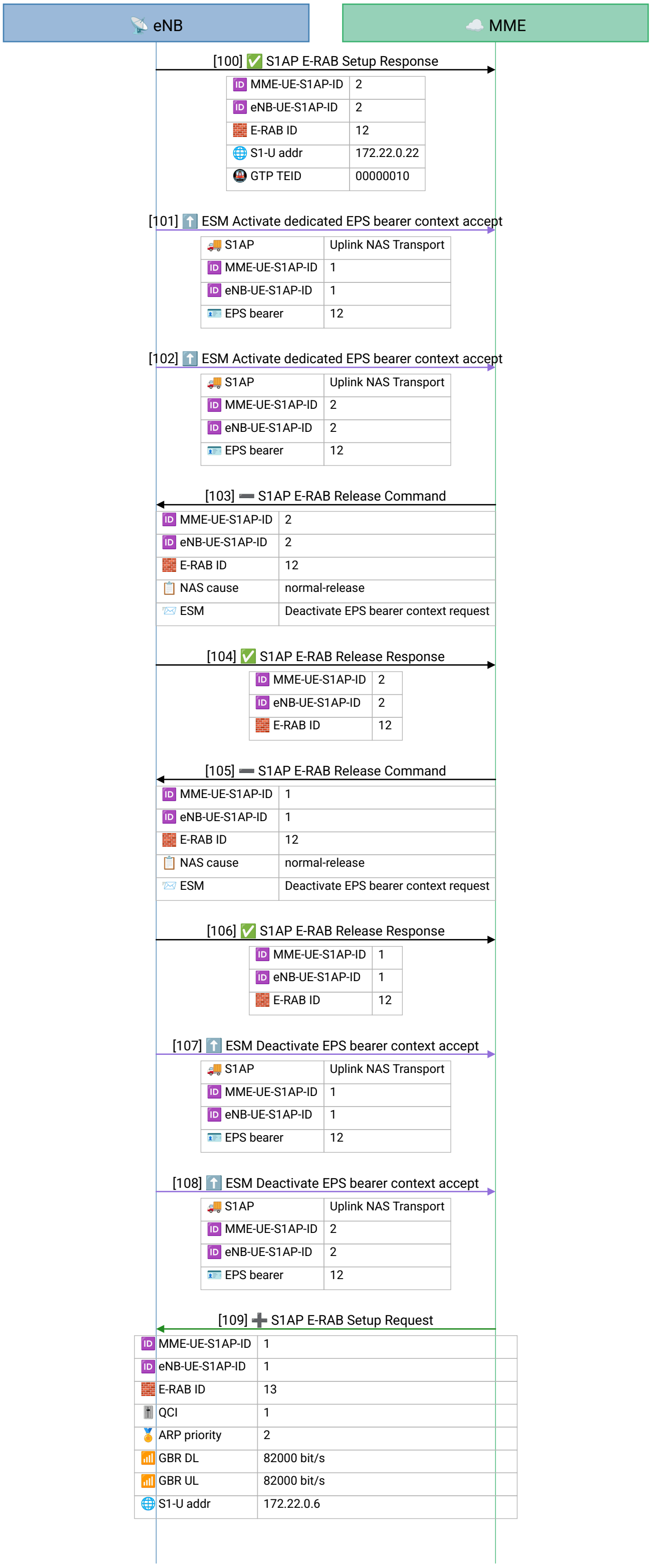
MME-UE-S1AP-ID	1
eNB-UE-S1AP-ID	1
E-RAB ID	12
S1-U addr	172.22.0.22
GTP TEID	0000000f

[Frame 98] E-RAB Setup Response.

[99] S1AP E-RAB Setup Request

MME-UE-S1AP-ID	2
eNB-UE-S1AP-ID	2
E-RAB ID	12
QCI	1
ARP priority	2
GBR DL	82000 bit/s
GBR UL	82000 bit/s
S1-U addr	172.22.0.6
GTP TEID	0000001e
ESM	Activate dedicated EPS bearer context request

[Frame 99] E-RAB 12 for UE 71.



[Frame 100] E-RAB Setup Response.

[Frame 101] UE 70 accepts.

[Frame 102] UE 71 accepts.

[Frame 103] Call 6 ends after 6.1 s: Release Command, UE 71.

[Frame 104] E-RAB Release Response.

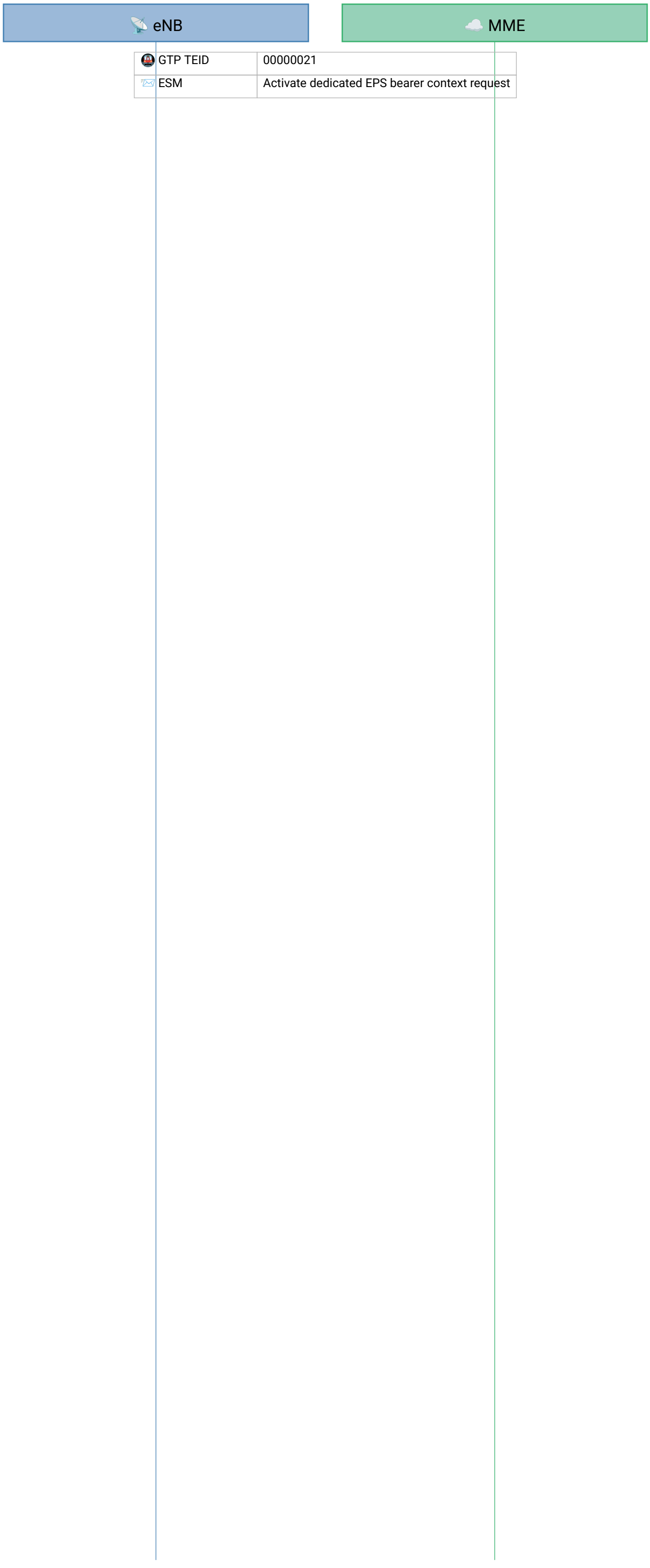
[Frame 105] Release Command, UE 70.

[Frame 106] E-RAB Release Response.

[Frame 107] UE 70's Deactivate accept.

[Frame 108] UE 71's Deactivate accept.

[Frame 109] A seventh call begins as the log ends. E-RAB 13 for UE 70, the callee of a call UE 71 dialed 89 ms earlier. The radio capture stopped 3 ms before this message, so this bearer never appears on the air interface. No UE Context Release appears anywhere: both phones stay connected to the end.


eNB
MME
GTP TEID
00000021
ESM
Activate dedicated EPS bearer context request