

OAI: Run CN, RAN and UE Platform

ECE 5984: 5G-Advanced, O-RAN & 6G
Virginia Tech

Run Core Network – Terminal 1

```
cd ~/oai-cn5g  
docker compose up -d
```

```
pratheek@Pratheek:~/oai-cn5g$ docker compose up -d  
[+] Running 11/11  
✓ Network oai-cn5g-public-net  Created  
✓ Container oai-nrf          Started  
✓ Container oai-ext-dn        Started  
✓ Container ims              Started  
✓ Container mysql             Started  
✓ Container oai-udr           Started  
✓ Container oai-udm           Started  
✓ Container oai-ausf          Started  
✓ Container oai-amf           Started  
✓ Container oai-smf           Started  
✓ Container oai-upf           Started
```

Check if all CN containers are healthy

```
docker ps -a
```

CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS
6148faa592b2	oaisoftwarealliance/oai-upf:develop oai-upf	"sh /openair-upf/bin..."	55 minutes ago	Up 55 minutes (healthy)	2152/udp, 8805/udp, 5342-5344/tcp
4de375a88bfc	oaisoftwarealliance/oai-smf:develop 9090/tcp, 8805/udp oai-smf	"/openair-smf/bin/oa..."	55 minutes ago	Up 55 minutes (healthy)	80/tcp, 5342-5344/tcp, 8080/tcp,
586dfa465dd8	oaisoftwarealliance/oai-amf:develop 9090/tcp, 38412/sctp oai-amf	"/openair-amf/bin/oa..."	55 minutes ago	Up 55 minutes (healthy)	80/tcp, 5342-5344/tcp, 8080/tcp,
a9abb0e79235	oaisoftwarealliance/oai-ausf:develop oai-ausf	"/openair-ausf/bin/o..."	55 minutes ago	Up 55 minutes (healthy)	80/tcp, 5342-5344/tcp, 8080/tcp
f318f32a76e1	oaisoftwarealliance/oai-udm:develop oai-udm	"/openair-udm/bin/oa..."	55 minutes ago	Up 55 minutes (healthy)	80/tcp, 5342-5344/tcp, 8080/tcp
3f54c5cbe03f	oaisoftwarealliance/oai-udr:develop oai-udr	"/openair-udr/bin/oa..."	55 minutes ago	Up 55 minutes (healthy)	80/tcp, 8080/tcp
817699455a6c	oaisoftwarealliance/oai-nrf:develop oai-nrf	"/openair-nrf/bin/oa..."	55 minutes ago	Up 55 minutes (healthy)	80/tcp, 5342-5344/tcp, 8080/tcp
260c02a90bd5	mysql:8.0 mysql	"docker-entrypoint.s..."	55 minutes ago	Up 55 minutes (healthy)	3306/tcp, 33060/tcp
87bdda0809dc	oaisoftwarealliance/trf-gen-cn5g:jammy oai-ext-dn	"/bin/bash -c ' ip r..."	55 minutes ago	Up 55 minutes (healthy)	
8527a4bf33f3	oaisoftwarealliance/ims:latest ims	"asterisk -fp"	55 minutes ago	Up 55 minutes (healthy)	

All containers should be
“healthy”

Run gNB – Terminal 2

- To open a new ubuntu session terminal – open a new PowerShell terminal and type,

```
wsl -d Ubuntu
```

- Edit the gNB configuration file to disable E2 agent (for now since we haven't installed flexRIC yet).

```
cd ~/openairinterface5g/targets/PROJECTS/GENERIC-NR-5GC/CONF/  
vim gnb.sa.band78.fr1.106PRB.usrp210.conf
```

```
#e2_agent = {  
#  near_ric_ip_addr = "127.0.0.1";  
#  #sm_dir = "/path/where/the/SMs/are/located/"  
#  sm_dir = "/usr/local/lib/flexric/"  
#};
```

Comment out these lines at
the end of the file as shown

Run gNB – Terminal 2

```
cd ~/openairinterface5g/cmake_targets/ran_build/build
```

```
sudo ./nr-softmodem -O ../../targets/PROJECTS/GENERIC-NR-  
5GC/CONF/gnb.sa.band78.fr1.106PRB.usrp210.conf --  
gNBs.[0].min_rxrtxtime 6 --rfsim
```

```
[HW] Version: Branch: develop Abrev. Hash: d47eb536b0 Date: Mon Aug 5 16:46:43 2024 +0000  
[NR_PHY] RC.gNB = 0x5bbb92c42920  
[NR_PHY] PRB blacklist  
[NR_PHY] Copying 0 blacklisted PRB to L1 context  
[PHY] L1_RX_THREAD_CORE -1 (15)  
[PHY] TX_AMP = 519 (-36 dBFS)  
Initializing northbound interface for L1  
[PHY] l1_north_init_gNB() RC.nb_nr_L1_inst:1  
[PHY] Installing callbacks for IF_Module - UL_indication  
[MAC] Allocating shared L1/L2 interface structure for instance 0 @ 0x5bbb92c4ad30  
[PHY] l1_north_init_gNB() RC.gNB[0] installing callbacks  
[PHY] create_gNB_tasks() Task ready initialize structures  
[PHY] No prs_config configuration found !!  
[GNB_APP] pdsch_AntennaPorts N1 1 N2 1 XP 1 pusch_AntennaPorts 1  
[GNB_APP] minTXRTIME 2  
[GNB_APP] SIB1 TDA 1  
[GNB_APP] CSI-RS 1, SRS 1, 256 QAM may be on, delta_MCS off, maxMIMO_Layers -1, HARQ feedback enabled  
[GNB_APP] sr_ProhibitTimer 0, sr_TransMax 64, sr_ProhibitTimer_v1700 0, t300 400, t301 400, t310 2000, n310 10, t311 3000,  
[RRC] Read in ServingCellConfigCommon (PhysCellId 0, ABSFREQSSB 641280, DLBand 78, ABSFREQPOINTA 640008, DLBW 106, RACH_Targ  
[RRC] absoluteFrequencySSB 641280 corresponds to 3619200000 Hz  
[MAC] [MAIN] Init function start:nb_nr_macrlc_inst=1  
[UTIL] threadCreate() for MAC_STATS: creating thread with affinity ffffffff, priority 2  
[PHY] Installing callbacks for IF_Module - UL_indication  
[NR_MAC] Configuring common parameters from NR ServingCellConfig  
[NR_MAC] DL_Bandwidth:40  
[NR_MAC] DL_Bandwidth:40  
[NR_MAC] ssb_OffsetPointA 86, ssb_SubcarrierOffset 0  
[NR_MAC] Set RX antenna number to 1, Set TX antenna number to 1 (num ssb 1: 80000000,0)  
[NR_MAC] Setting TDD configuration period to 6  
DL frequency 3619200000: band 48, UL frequency 3619200000  
[PHY] DL frequency 3619200000 Hz, UL frequency 3619200000 Hz: band 48, uldl offset 0 Hz  
[PHY] Configuring MIB for instance 0, : (id_cell 0,DL freq 3619200000, UL freq 3619200000)  
[PHY] Initializing frame parms for mu 1, L_RB 106, Ncp 0  
[PHY] Init: N_RB_DL 106, first_carrier_offset 1412, nb_prefix_samples 144, nb_prefix_samples0 176, ofdm_symbol_size 2048  
[PHY] Doing symbol rotation calculation for TX/RX, f0 3619200000.000000 Hz, Nsymb 28  
[PHY] Doing symbol rotation calculation for TX/RX, f0 3619200000.000000 Hz, Nsymb 28  
[PHY] gNB 0 configured
```

gNB configuration – Look for
CSI-RS, SRS settings, MIB,
DL/UL freq.

Check AMF logs in Core Network Terminal

```
docker logs oai-amf -f
```

```
}
```

```
[2025-10-07 20:49:13.168] [ngap] [debug] Encoded size (49)
[2025-10-07 20:49:13.168] [sctp] [debug] [Socket 4, Assoc ID 4] Sending buffer 0x7f3ff0000e00 of 49 bytes on stream 0 with PPID 60
[2025-10-07 20:49:13.168] [sctp] [debug] Successfully sent 49 bytes on stream 0
[2025-10-07 20:49:13.168] [amf_n2] [debug] Sending NG_SETUP_RESPONSE Ok
[2025-10-07 20:49:13.168] [amf_n2] [debug] gNB with gNB_id 0xe00, assoc_id 4 has been attached to AMF
[2025-10-07 20:49:13.169] [amf_app] [debug] A new gNB has been successfully added!
[2025-10-07 20:49:13.169] [ngap] [debug] Free NGAP Message PDU
[2025-10-07 20:49:13.169] [ngap] [debug] Free NGAP Message PDU
[2025-10-07 20:49:14.795] [amf_app] [debug] Send ITTI msg to SBI task to trigger NRF Heartbeat
[2025-10-07 20:49:14.795] [amf_sbi] [info] Receive Update NF Instance Request, handling ...
[2025-10-07 20:49:14.795] [amf_sbi] [debug] Send NF Update to NRF
[2025-10-07 20:49:14.795] [amf_sbi] [info] Send HTTP message to http://oai-nrf:8080/nnrf-nfm/v1/nf-instances/01f5098b-62aa-4960-bd66-d9725a515b26
[2025-10-07 20:49:14.795] [amf_sbi] [info] HTTP message Body: [{"op": "replace", "path": "/nfStatus", "value": "REGISTERED"}]
[2025-10-07 20:49:14.795] [amf_sbi] [debug] Send a simple HTTP request
[2025-10-07 20:49:14.797] [amf_sbi] [info] Get response with HTTP code (204)
[2025-10-07 20:49:14.798] [amf_sbi] [info] Could not get JSON content from the response
[2025-10-07 20:49:14.798] [amf_app] [debug] Received SBI_UPDATE_NF_INSTANCE_RESPONSE
[2025-10-07 20:49:14.798] [amf_app] [debug] Handle NF Update response
[2025-10-07 20:49:14.798] [amf_app] [debug] Set a timer to the next Heart-beat (10)
[2025-10-07 20:49:18.889] [amf_app] [info]
```

gNBs' Information					
Index	Status	Global Id	gNB Name	PLMN	
1	Connected	0x0E00	gNB-OAI	001,01	

UEs' Information							
Index	5GMM State	IMSI	GUTI	RAN UE NGAP ID	AMF UE NGAP ID	PLMN	Cell Id
-	-	-	-	-	-	-	-

```
[2025-10-07 20:49:24.798] [amf_app] [debug] Send TTTT msg to SBT task to trigger NRF Heartbeat
```

Run the UE – Terminal 3

```
cd  
~/openairinterface5g/cmake_targets/ran_buil  
d/build
```

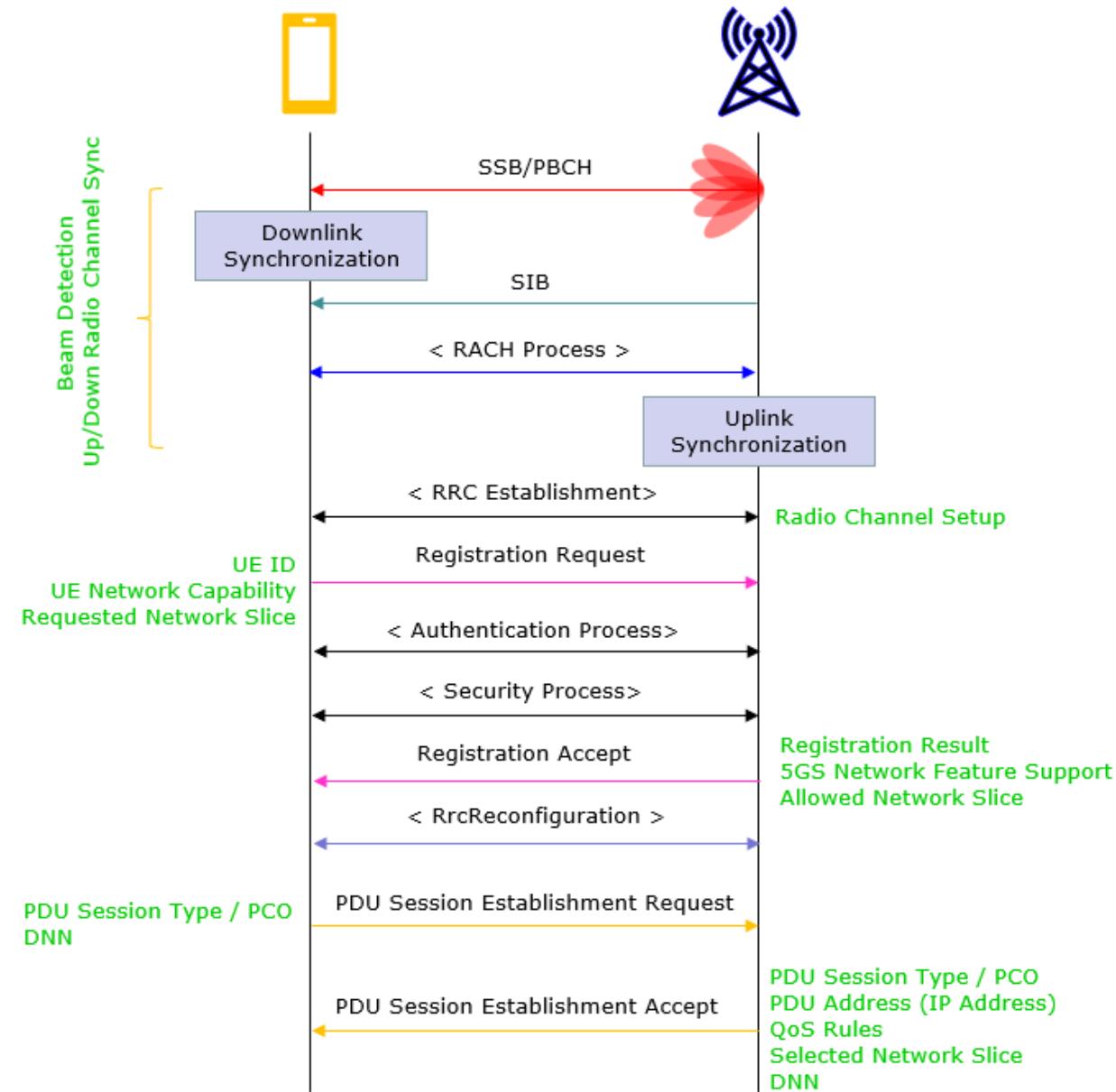
```
sudo ./nr-uesoftmodem -r 106 --numerology 1  
--band 78 -C 3619200000 --uicc0.imsi  
00101000000001 --rfsim
```

```
[HW]  Connected to 127.0.0.1:4043 failed, errno(0)  
[PHY]  SSB position provided  
[NR_PHY]  Starting sync detection  
[PHY]  [UE thread Sync] Running Initial Synch  
[NR_PHY]  Starting cell search with center freq: 3619200000, bandwidth: 106. Scanning for 1 number of GSCN.  
[NR_PHY]  Scanning GSCN: 0, with SSB offset: 516, SSB Freq: 0.000000  
[PHY]  Initial sync: pbch decoded successfully, ssb index 0  
[PHY]  pbch rx ok. rsrp:51 dB/RE, adjust_rxgain:-1 dB  
[NR_PHY]  Cell Detected with GSCN: 0, SSB SC offset: 516, SSB Ref: 0.000000, PSS Corr peak: 99 dB, PSS Corr Average: 61  
[PHY]  [UE0] In synch, rx_offset 276480 samples  
[PHY]  [UE 0] Measured Carrier Frequency offset 16 Hz  
[PHY]  Initial sync successful, PCI: 0  
[PHY]  HW: Configuring channel 0 (rf_chain 0): setting tx_freq 3619200016 Hz, rx_freq 3619200016 Hz, tune_offset 0  
[PHY]  Got synch: hw_slot_offset 18, carrier off 16 Hz, rxgain 0.000000 (DL 3619200016.000000 Hz, UL 3619200016.000000 Hz)  
[PHY]  UE synchronized! decoded_frame_rx=484 UE->init_sync_frame=0 trashed_frames=56  
[PHY]  Resynchronizing RX by 276480 samples  
[HW]  received write reorder clear context  
[HW]  Gap in writing to USRP: last written 1590681599, now 1590772959, gap 91360  
[NR_RRC]  SIB1 decoded  
[NR_PHY]  =====  
[NR_PHY]  [UE 0] Harq round stats for Downlink: 1/0/0  
[NR_PHY]  =====  
[NR_MAC]  Initialization of 4-step contention-based random access procedure  
[NR_MAC]  PRACH scheduler: Selected R0 Frame 631, Slot 19, Symbol 0, Fdm 0  
[PHY]  PRACH [UE 0] in frame.slot 631.19, placing PRACH in position 2828, msg1 frequency start 0 (k1 0), preamble_offset 9,  
[NR_MAC]  Trying to process acknack for an inactive harq process (0)  
[NR_MAC]  [UE 0][RAPROC][RA-RNTI 0005] Got BI RAR subPDU 267 ms  
[NR_MAC]  [UE 0][RAPROC][RA-RNTI 010b] Got RAPID RAR subPDU  
[NR_MAC]  [UE 0][RAPROC][632.7] Found RAR with the intended RAPID 37  
[MAC]  received TA command 31  
[PHY]  RAR-Msg2 decoded  
[NR_MAC]  [RAPROC][632.17] RA-Msg3 transmitted  
[MAC]  [UE 0]Frame 633 Contention resolution identity: 0x15c608f230e6 Terminating RA procedure  
[MAC]  [UE 0][633.12][RAPROC] RA procedure succeeded. CB-RA: Contention Resolution is successful.  
[NR_RRC]  [UE0][RAPROC] Logical Channel DL-CCCH (SRB0), Received NR_RRCSetup  
[RLC]  Added srb 1 to UE 0  
[MAC]  [UE 0] Applying CellGroupConfig from gNodeB  
[NR_RRC]  State = NR_RRC_CONNECTED  
[NR_RRC]  [UE 0][RAPROC] Logical Channel UL-DCCH (SRB1), Generating RRCSsetupComplete (bytes33)
```

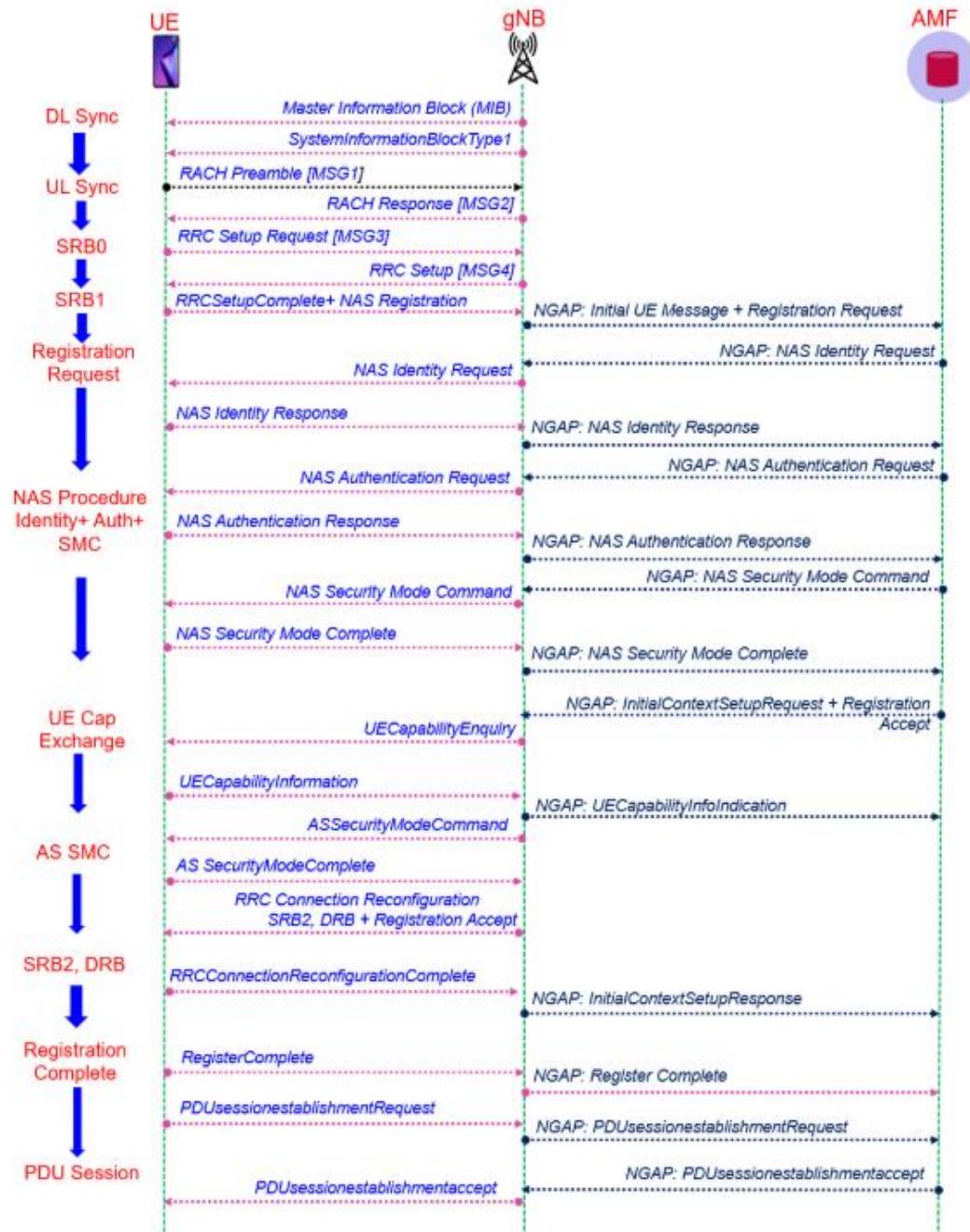
- Check the AMF logs again and verify if the UE is “registered”.

UE registration Call flow

- Trace the UE registration with the gNB and CN



Detailed UE registration call flow



gNB output Interpretation

```
[NR_MAC] Frame.Slot 768.0
UE RNTI 8f47 CU-UE-ID 1 in-sync PH 52 dB PCMAX 20 dBm, average RSRP -44 (16 meas)
UE 8f47: UL-RI 1, TPMI 0
UE 8f47: dlsch_rounds 14/1/0/0, dlsch_errors 0, pucch0_DTX 0, BLER 0.07290 MCS (0) 9
UE 8f47: ulsch_rounds 29/1/0/0, ulsch_errors 0, ulsch_DTX 0, BLER 0.12138 MCS (0) 9 (Qm 2 dB) NPRB 5 SNR 51.0 dB
UE 8f47: MAC: TX 1833 RX 1652 bytes
UE 8f47: LCID 1: TX 531 RX 290 bytes
UE 8f47: LCID 2: TX 0 RX 0 bytes
UE 8f47: LCID 4: TX 0 RX 0 bytes

[NR_MAC] Frame.Slot 896.0
UE RNTI 8f47 CU-UE-ID 1 in-sync PH 52 dB PCMAX 20 dBm, average RSRP -44 (16 meas)
```

- The scheduler periodically outputs statistics that can help you judge the radio channel quality.
- In the first line,
 - UE RNTI
 - PH: Power Headroom - the amount of power the UE has left.
 - RSRP: measured power of the DL reference signals at the UE.
 - SINR: measured signal to interference and noise ratio of the SSB received at the UE.
- *LCID X* shows the amount of MAC SDU/RLC PDU data for Logical Channel ID with ID X in transmit and receive directions.
 - LCIDs 1 and 2 are mapped to SRBs 1 and 2.
 - LCIDs 4 and onward are mapped to DRBs 1 onward.
 - If you have an LCID 4, it means you have a PDU session.