Project Status, Progress, Planning

Tyler Bibus

This covers the main projects for REU Tyler Bibus over Summer 2025. With daily reports starting in July (as it was requested then).

Sections:

SrsRAN Project

Goals:

SrsRAN is an open source 5G network stack like OAI. SrsRAN does not natively support GPIO pin control, meaning it cannot be used with amplifiers outdoors.

Main Goal: Modify srsRAN to work with amplifiers via GPIO toggling.

Progress-Planning:

- COMPLETED: Figure out how to control GPIO Pins on UHD
- COMPLETED: Get GPIO Pin Timing to align with 5G TDD Frame.
- COMPLETED: Test with/without amplifier, comparing connectivity
- COMPLETED: Test with USRP N320 with amplifier
- COMPLETED: Test outdoors with 500 & 510 Quectel (Waiting for a cable)
- IN-PROGRESS: Finalize deployment onto ARA Network (Containerize experiments)

Problems Encountered:

Set-up open5gs with srsRAN:

I initially encountered trouble when setting up srsRAN initially, this was primarily caused by my inexperience with 5G and open source software.

> **Solution:** My solution to this was retrying while following the tutorial closely, documenting which steps worked and what changes I had to make. These critical steps can be found in a Sphinx Document (***TODO: upload to git***).

Improper GPIO timing:

I had gotten the GPIO pins to change utilizing a function in *lib/radio/uhd/radio_uhd_tx_stream.cpp* however the tx function did not work as expected, rather toggling every 0.5ms rather than just during DL.

Solution: I was able to utilize the POWDER patch on release 23_10 to properly set the GPIO timing.

No transmission on BS, loss of transmission on NUC (POWDER patch)

After successfully testing the POWDER patch in 91 Durham, we moved to a BS server to run srsRAN on a N320. This proved to cause a problem where the TX would break shortly after starting the program. *Note: This wouldn't appear in any logs, the TX (red) light would turn off*

Solution: This was solved by making light modifications to the POWDER Patch, by commenting out all the UNDERFLOW_RECOVERY State related code. This state would cause the gNB to get stuck.

Mender/CI-CD Project

Goals:

Mender: Create a way to do a mass deployment to update the UHD version on all BS and UHD Filesystems.

CI-CD: Create a pipeline to verify the experiments. (This has been put on hold in place for mender until later notice).

Progress-Planning:

Mender:

- COMPLETED: Build a mock server (NUC)
- COMPLETED: Connect a mock client (Different NUC)
- COMPLETED: Launch a test update using the mender server
- COMPLETED: Find a way to update UHD Filesystem remotely.
- IN-PROGRESS: Develop an artifact to update UHD Drivers on host machine
- FUTURE: Deploy a server, connect BS towers
- FUTURE: Build and launch deployment to update UHD Drivers and Filesystems

CI/CD: (CURRENTLY ON HOLD, could be future project when I complete other projects)

Problems Encountered:

Mender server set-up issues:

Setting up the mender server created some unique problems I haven't faced before. The main problem was that we needed a domain to connect to, not just an IP address.

Solution: This is a temporary solution unless you have a static IP, you can add a domain name to /etc/hosts. For example, the server set-up I used mender.example.com as the domain, with the server IP. This step needs to be done on the server and EVERY client.

Uploading the UHD filesystem artifact

UHD provides a mender artifact to update the filesystem for their radios. I do not believe this updates the host machine as well, but it could be worth investigating. Currently on the mock server, it will fail when trying to upload the image. This is likely due to its larger size compared to the size of the mock server.

Potential Solution: By using a more powerful server it might just let us upload it. Otherwise a load-balancer would likely solve the issue.

Alternative: You do not need a dedicated server to deploy the filesystem upgrade, you can just run the mender command with the file. This has the downside of potentially limiting the deployment speed as you would need to do it for each tower, but it is still more effective than pulling the N320s down to update from SD card.

OpenAirInterface Update Project:

OpenAirInterface (OAI) is the primary open source 5G stack we use for both gNB and UE for testing. Our current patch to run it outdoors is out of date and needs to be updated.

Goals:

The primary goal is to update the patch to the latest develop branch. This includes both outdoor GPIO toggling as well as updating the scheduling for Msg2 and Msg3 to improve outdoor latching.

Progress-Planning:

- COMPLETED: Set-up small test bench with unpatched latest develop
- COMPLETED: Apply GPIO, UE, patches
- COMPLETED: Apply a modified version of the gNB patch
- COMPLETED: Initial testing with NEMO Handy to ensure that latching passes properly.
- COMPLETED: Test patch in ARA Sandbox.
- IN-PROGRESS: Modify patch to take values from a config file, rather than hardcoded values.

- COMPLETED: Test patch in outdoor environment
- IN-PROGRESS: Work with OAI members to incorporate patch into official repository.

Problems Encountered:

OAI Crashes immediately after Msg4 Acknowledgement

The UE would successfully exchange Msg1-4 but then OAI would have a segmentation fault and crash. Utilizing *gdb* I was able to debug the segmentation fault, and found that it was a null pointer exception related to *dmrs_IplinkForPUSCH_MappingTypeB->choice.setup*.

Solution: The modifications I made had changed the struct NR_PUSH_TimeDomainResourceAllocation = CALLOC(……) rather than = set_TimeDoaminResourceAllocation(…)
This caused the struct to be missing values that were called in other functions, triggering a null pointer exception.
After using the proper function to allocate the struct, it no longer crashes and allows the NEMO Handy to connect to the gNB.

With my patch I had been encountering an issue with the Hybrid Automatic Repeat Request (HARQ). This limited throughput significantly (~2Mbps). This was fixed by readding the TDA index 2 which had been accidentally removed before I understood it.

Adding Values to configs

I have found and added the values (msg2_slot) and k2_msg3 in the nr_mac_config_t structure. This should be accessible anywhere with

RC.nrmac[module_ip]->radio_config.k2_msg3

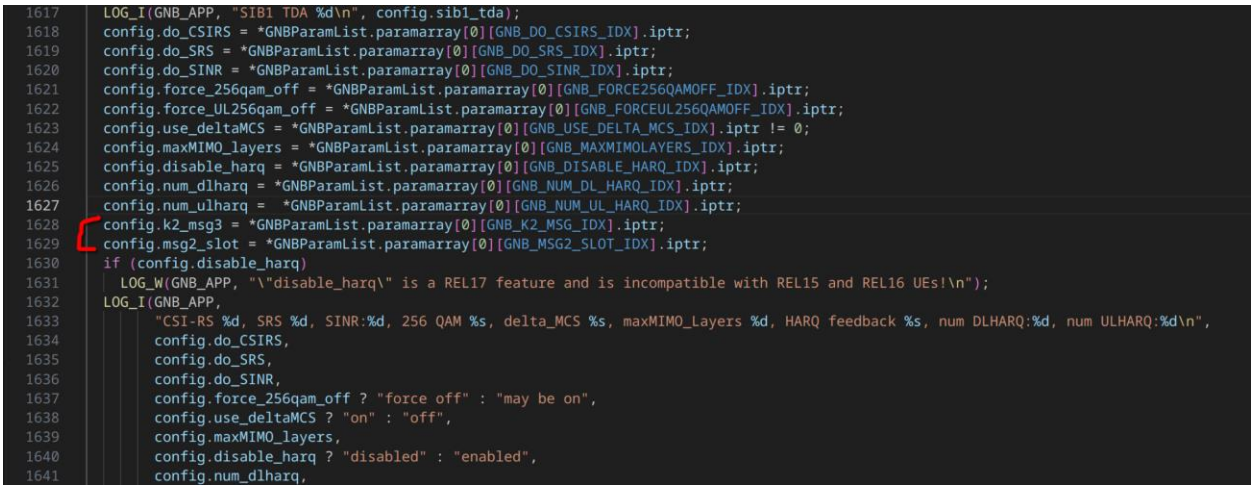
This was acomplished by adding the following to /openair2/GNB_APP/gnb_paramdef.h

```
187  {GNB_CONFIG_STRING_NRCELLID,                  NULL,   0,            .u64ptr=NULL,.defint64val=1,              TYPE_UINT64,    0},  \
188  {GNB_CONFIG_STRING_MINRXTXTIME,               NULL,   0,            .iptr=NULL,  .defintval=2,                TYPE_INT,       0},  \
189  {GNB_CONFIG_STRING_ULPRBBLACKLIST,            NULL,   0,            .strptr=NULL,.defstrval="",               TYPE_STRING,    0},  \
190  {GNB_CONFIG_STRING_UMONDEFAULTDRB,            NULL, PARAMFLAG_BOOL, .uptr=NULL,  .defuintval=0,               TYPE_UINT,      0},  \
191  {GNB_CONFIG_STRING_FORCE256QAMOFF, GNB_CONFIG_HLP_FORCE256QAMOFF, PARAMFLAG_BOOL, .iptr=NULL, .defintval=0,     TYPE_INT,       0},  \
192  {GNB_CONFIG_STRING_ENABLE_SDAP, GNB_CONFIG_HLP_STRING_ENABLE_SDAP, PARAMFLAG_BOOL,.iptr=NULL, .defintval=0,    TYPE_INT,       0},  \
193  {GNB_CONFIG_STRING_DRBS, GNB_CONFIG_HLP_STRING_DRBS,     0,           .iptr=NULL,   .defintval=1,                TYPE_INT,       0},  \
194  {GNB_CONFIG_STRING_GNB_DU_ID, GNB_CONFIG_HLP_GNB_DU_ID,  0,           .u64ptr=NULL, .defint64val=1,              TYPE_UINT64,    0},  \
195  {GNB_CONFIG_STRING_GNB_CU_UP_ID, GNB_CONFIG_HLP_GNB_CU_UP_ID, 0,      .u64ptr=NULL, .defint64val=1,              TYPE_UINT64,    0},  \
196  {GNB_CONFIG_STRING_USE_DELTA_MCS, GNB_CONFIG_HLP_USE_DELTA_MCS, 0,    .iptr=NULL,   .defintval=0,                TYPE_INT,       0},  \
197  {GNB_CONFIG_STRING_FORCEUL256QAMOFF, GNB_CONFIG_HLP_FORCEUL256QAMOFF, 0,.iptr=NULL, .defintval=0,                TYPE_INT,       0},  \
198  {GNB_CONFIG_STRING_MAXMIMOLAYERS, GNB_CONFIG_HLP_MAXMIMOLAYERS, 0,    .iptr=NULL,   .defintval=-1,               TYPE_INT,       0},  \
199  {GNB_CONFIG_STRING_DISABLE_HARQ, GNB_CONFIG_HLP_DISABLE_HARQ, PARAMFLAG_BOOL, .iptr=NULL, .defintval=0,          TYPE_INT,       0},  \
200  {GNB_CONFIG_STRING_NUM_DL_HARQPROCESSES, GNB_CONFIG_HLP_NUM_DL_HARQ, 0, .iptr=NULL, .defintval=16,               TYPE_INT,       0},  \
201  {GNB_CONFIG_STRING_NUM_UL_HARQPROCESSES, GNB_CONFIG_HLP_NUM_UL_HARQ, 0, .iptr=NULL, .defintval=16,               TYPE_INT,       0},  \
202  {GNB_CONFIG_STRING_UESS_AGG_LEVEL_LIST, \
203                GNB_CONFIG_HLP_UESS_AGG_LEVEL_LIST,  0,       .iptr=NULL,       .defintarrayval=NULL,          TYPE_INTARRAY,  0},  \
204  {GNB_CONFIG_STRING_CU_SIB_LIST,               GNB_CONFIG_HLP_CU_SIBS, 0, .iptr=NULL, .defintarrayval=0,       TYPE_INTARRAY,  0},  \
205  {GNB_CONFIG_STRING_DU_SIB_LIST,               GNB_CONFIG_HLP_DU_SIBS, 0, .iptr=NULL, .defintarrayval=0,       TYPE_INTARRAY,  0},  \
206  {GNB_CONFIG_STRING_DOSINR,      GNB_CONFIG_HLP_DOSINR,   0,           .iptr=NULL,   .defintval=0,                TYPE_INT,       0},  \
207  {GNB_CONFIG_STRING_K2_MSG3,      NULL,   0,                          .iptr=NULL,   .defintval=9,                TYPE_INT,       0},  \
208  {GNB_CONFIG_STRING_MSG2_SLOT,      NULL,   0,                        .iptr=NULL,   .defintval=6,                TYPE_INT,       0},  \
209  }
210  // clang-format on
```

```
237  #define GNB_ENABLE_SDAP_IDX             25
238  #define GNB_DRBS                        26
239  #define GNB_GNB_DU_ID_IDX               27
240  #define GNB_GNB_CU_UP_ID_IDX            28
241  #define GNB_USE_DELTA_MCS_IDX           29
242  #define GNB_FORCEUL256QAMOFF_IDX        30
243  #define GNB_MAXMIMOLAYERS_IDX           31
244  #define GNB_DISABLE_HARQ_IDX            32
245  #define GNB_NUM_DL_HARQ_IDX             33
246  #define GNB_NUM_UL_HARQ_IDX             34
247  #define GNB_UESS_AGG_LEVEL_LIST_IDX     35
248  #define GNB_CU_SIBS_IDX                 36
249  #define GNB_DU_SIBS_IDX                 37
250  #define GNB_DO_SINR_IDX                 38
251  #define GNB_K2_MSG_IDX                  39
252  #define GNB_MSG2_SLOT_IDX               40
253
254  #define TRACKING_AREA_CODE_OKRANGE {0x0001,0xFFFD}
255  #define NUM_DL_HARQ_OKVALUES {2,4,6,8,10,12,16,32}
256  #define NUM_UL_HARQ_OKVALUES {16,32}
257
258  #define GNBPARAMS_CHECK {                                       \
259    { .s5 = { NULL } },                                           \
260    { .s5 = { NULL } },                                           \
261    { .s5 = { NULL } },                                           \
```

```
280    { .s5 = { NULL } },                                          \
281    { .s5 = { NULL } },                                          \
282    { .s5 = { NULL } },                                          \
283    { .s5 = { NULL } },                                          \
284    { .s5 = { NULL } },                                          \
285    { .s5 = { NULL } },                                          \
286    { .s5 = { NULL } },                                          \
287    { .s5 = { NULL } },                                          \
288    { .s5 = { NULL } },                                          \
289    { .s5 = { NULL } },                                          \
290    { .s5 = { NULL } },                                          \
291    { .s5 = { NULL } },                                          \
292    { .s1 =  { config_check_intval, NUM_DL_HARQ_OKVALUES,8 } },   \
293    { .s1 =  { config_check_intval, NUM_UL_HARQ_OKVALUES,2 } },   \
294    { .s5 = { NULL } },                                          \
295    { .s5 = { NULL } },                                          \
296    { .s5 = { NULL } },                                          \
297    { .s5 = { NULL } },                                          \
298    { .s5 = { NULL } },                                          \
299    { .s5 = { NULL } },                                          \
300  }
301
302  /*---------------------------------------------------------------------------------------------------------------*/
303  /*---------------------------------------------------------------------------------------------------------------*/
```

Adding the following lines in /openair2/GNB_APP/gnb_config.c



```
1617  LOG_I(GNB_APP, "SIB1 TDA %d\n", config.sib1_tda);
1618  config.do_CSIRS = *GNBParamList.paramarray[0][GNB_DO_CSIRS_IDX].iptr;
1619  config.do_SRS = *GNBParamList.paramarray[0][GNB_DO_SRS_IDX].iptr;
1620  config.do_SINR = *GNBParamList.paramarray[0][GNB_DO_SINR_IDX].iptr;
1621  config.force_256qam_off = *GNBParamList.paramarray[0][GNB_FORCE256QAMOFF_IDX].iptr;
1622  config.force_UL256qam_off = *GNBParamList.paramarray[0][GNB_FORCEUL256QAMOFF_IDX].iptr;
1623  config.use_deltaMCS = *GNBParamList.paramarray[0][GNB_USE_DELTA_MCS_IDX].iptr != 0;
1624  config.maxMIMO_layers = *GNBParamList.paramarray[0][GNB_MAXMIMOLAYERS_IDX].iptr;
1625  config.disable_harq = *GNBParamList.paramarray[0][GNB_DISABLE_HARQ_IDX].iptr;
1626  config.num_dlharq = *GNBParamList.paramarray[0][GNB_NUM_DL_HARQ_IDX].iptr;
1627  config.num_ulharq =  *GNBParamList.paramarray[0][GNB_NUM_UL_HARQ_IDX].iptr;
1628  config.k2_msg3 = *GNBParamList.paramarray[0][GNB_K2_MSG_IDX].iptr;
1629  config.msg2_slot = *GNBParamList.paramarray[0][GNB_MSG2_SLOT_IDX].iptr;
1630  if (config.disable_harq)
1631    LOG_W(GNB_APP, "\"disable_harq\" is a REL17 feature and is incompatible with REL15 and REL16 UEs!\n");
1632  LOG_I(GNB_APP,
1633        "CSI-RS %d, SRS %d, SINR:%d, 256 QAM %s, delta_MCS %s, maxMIMO_Layers %d, HARQ feedback %s, num DLHARQ:%d, num ULHARQ:%d\n",
1634        config.do_CSIRS,
1635        config.do_SRS,
1636        config.do_SINR,
1637        config.force_256qam_off ? "force off" : "may be on",
1638        config.use_deltaMCS ? "on" : "off",
1639        config.maxMIMO_layers,
1640        config.disable_harq ? "disabled" : "enabled",
1641        config.num_dlharq,
```

Now, k2_msg3 and msg2_slot are accessible from:

RC.nrmac[module_itp]->radio_config.k2_msg3

Daily Progress:

TEMPLATE:

Date: XX/XX/2025

Plans/TODO:

- Create Documentation
- Build patches

Progress:

Successful in creating detailed documentation for ARAHual [insert screenshot]

Notes/Questions:

Encountered issue with patch [insert logs]

Is it going to be necessary to deploy this on the www?

Date: 07/01/2025

Plans/TODO:

- ☐ ~~Create summer progress documents for Joshua~~
- ☐ ~~Update OAI Git and share with Joshua~~
- ☐ ~~Test srsRAN (N320 & TMB) with 500 and 510 Quectel.~~
- ☐ ~~Reserve nodes, potentially test OAI Patch inside sandbox.~~

Progress:

Completed summer progress documents (Will be updated every workday).

Updated OAI git to reflect current docker container patch:

https://github.com/Tyler-Bibus/openairinterface5g_gpio

Cleaned and Pushed OAI Docker Container to DockerHub

Reserved leases for sandbox for July 2, 2025 (could not lease same-day)

srsRAN connected with both 500 AND 510 successfully (N320 + TMB).

Notes/Questions:

Note: outdoor srsRAN testing will occur when we get the cable (This week or next week).

Potential Problem: This latest develop release seems to ocassionaly crash (with and without patch). It is related to the prach where it PRACH is –1 (illegal). This bug is unreleated to ARA.

POTENTIAL PROBLEM!!: When running srsRAN again (did not change anything). A new bug appears inside of the logs. This is non-fatal in the sense it doesn't crash. But it might interfere with signals, I am not sure yet..
GNB Log:

```
Late: 1; Underflow: 0; Overflow: 0;
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Late: 1; Underflow: 2; Overflow: 0;
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Late: 0; Underflow: 1; Overflow: 0;
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Late: 0; Underflow: 1; Overflow: 0;
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Late: 0; Underflow: 1; Overflow: 0;
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Late: 0; Underflow: 2; Overflow: 0;
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Late: 1; Underflow: 1; Overflow: 0;
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Late: 1; Underflow: 2; Overflow: 0;
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
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Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
Error: failed receiving packet. RfnocError: OpTimeout: Control operation timed out waiting for ACK.
```

This appears to be a radio error. Meaning the connection between the computer and radio is breaking(?)

FIX: Reducing the tx gain in config from 50 to 45 fixed this issue.

Date: 07/02/2025

Plans/TODO:

- ~~☐ Run OAI test in sandbox from 12:00-3:00 pm.~~
- ~~☐ Write additional Documentation for OAI patch.~~
- ☐ Make modifications to OAI patch to pull values/calculate using config values dynamically (Include light testing).

Progress:

Cleaned up comments in OAI patch.
Ran OAI in sandbox lab, but ran into issues with OAI nrUE: see below

Notes/Questions:

Ara's website is giving me issues with having more than one lease active at once. (using device 014 appeared to work better)

OAI nrUE has an issue with synch:

```
[PHY]   synch Failed:
[PHY]   SSB position provided
[NR_PHY]   Starting sync detection
[PHY]   [UE thread Synch] Running Initial Synch
[NR_PHY]   Starting cell search with center freq: 3604800000, bandwidth: 106. Scanning for 1 number of GSCN.
[NR_PHY]   Scanning GSCN: 0, with SSB offset: 516, SSB Freq: 0.000000
[PHY]   synch Failed:
[PHY]   SSB position provided
[NR_PHY]   Starting sync detection
[PHY]   [UE thread Synch] Running Initial Synch
[NR_PHY]   Starting cell search with center freq: 3604800000, bandwidth: 106. Scanning for 1 number of GSCN.
[NR_PHY]   Scanning GSCN: 0, with SSB offset: 516, SSB Freq: 0.000000
[PHY]   synch Failed:
[PHY]   SSB position provided
[NR_PHY]   Starting sync detection
[PHY]   [UE thread Synch] Running Initial Synch
[NR_PHY]   Starting cell search with center freq: 3604800000, bandwidth: 106. Scanning for 1 number of GSCN.
[NR_PHY]   Scanning GSCN: 0, with SSB offset: 516, SSB Freq: 0.000000
[PHY]   synch Failed:
[PHY]   SSB position provided
[NR_PHY]   Starting sync detection
[PHY]   [UE thread Synch] Running Initial Synch
[NR_PHY]   Starting cell search with center freq: 3604800000, bandwidth: 106. Scanning for 1 number of GSCN.
[NR_PHY]   Scanning GSCN: 0, with SSB offset: 516, SSB Freq: 0.000000
```

This was resolved by picking correct gNB frequency values.

AbsoluteFrequencySSB = 640320;

Dl_absoluteFrequencyPointA = 639048; // These are for 3604.8 MHz

NACK Error on SIB1:

```
[PHY]   SSB position provided
[NR_PHY]   Starting sync detection
[PHY]   [UE thread Synch] Running Initial Synch
[NR_PHY]   Starting cell search with center freq: 3604800000, 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 sucessfully, 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 Ave
[PHY]   [UE0] In synch, rx_offset 413056 samples
[PHY]   [UE 0] Measured Carrier Frequency offset 28 Hz
[PHY]   Initial sync successful, PCI: 0
[PHY]   HW: Configuring channel 0 (rf_chain 0): setting tx_freq 3604800028 Hz, rx_freq 3604800028 Hz, tune_offse
Setting USRP TX Freq 3604800028.000000, RX Freq 3604800028.000000, tune_offset: 0.000000
[PHY]   Got synch: hw_slot_offset 36, carrier off 28 Hz, rxgain 66.000000 (DL 3604800028.000000 Hz, UL 360480002
[PHY]   UE synchronized! decoded_frame_rx=472 UE->init_sync_frame=1 trashed_frames=8
[PHY]   Resynchronizing RX by 413056 samples
[HW]   received write reorder clear context
[HW]   write_reorder_clear_context call while still writing on the device
[NR_MAC]   Got NACK on NR-BCCH-DL-SCH-Message (SIB1)
[NR_MAC]   Got NACK on NR-BCCH-DL-SCH-Message (SIB1)
[NR_MAC]   Got NACK on NR-BCCH-DL-SCH-Message (SIB1)
[NR_MAC]   Got NACK on NR-BCCH-DL-SCH-Message (SIB1)
[NR_MAC]   Got NACK on NR-BCCH-DL-SCH-Message (SIB1)
[NR_MAC]   Got NACK on NR-BCCH-DL-SCH-Message (SIB1)
[NR_MAC]   Got NACK on NR-BCCH-DL-SCH-Message (SIB1)
[NR_MAC]   Got NACK on NR-BCCH-DL-SCH-Message (SIB1)
[NR_MAC]   Got NACK on NR-BCCH-DL-SCH-Message (SIB1)
[NR_MAC]   Got NACK on NR-BCCH-DL-SCH-Message (SIB1)
[NR_MAC]   Got NACK on NR-BCCH-DL-SCH-Message (SIB1)
```

This has not been resolved, happens on both patched and unpatched OAI. (Could this have to do with IP not being set properly for core network?)

Date: 07/03/2025

Plans/TODO:

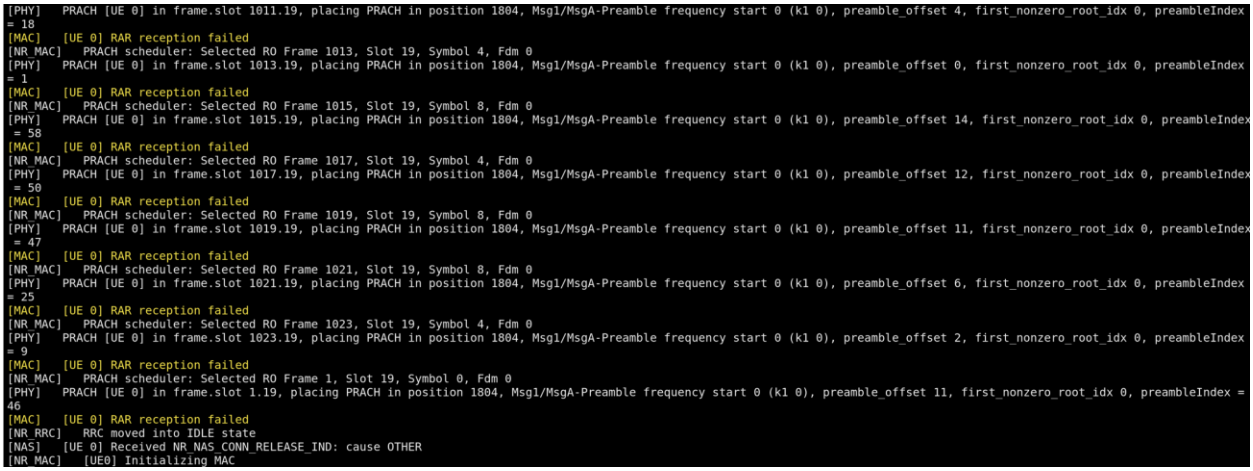
- ☐ Get unpatched OAI working on OAI sandbox
- ☐ Fix patch to be working properly in sandbox
- ☐ Update patch to use calculations OR config values instead of hardcoded vals

Progress:

Still running into *write_reorder_clear_context call while still writing on the device* error while trying to connect nrUE to gNB. I believe this could be caused by the UHD diver versions but I am not sure. This happens on both unpatched and patched versions.
It will then follow up with Got NACK on NR_BCCH_DL_SCH_Message (SIB1) until the program is shut down. Waiting until meeting with Joshua to explore more potential causes and solutions.

Notes/Questions:

This is what happens BEFORE the NACK error. I believe it is getting stuck before getting past Msg1.



Week 07/07-07/11

Date: 07/07/2025

Plans/TODO:

- ☐ ~~Get unpatched OAI working on OAI sandbox~~
- ☐ ~~Fix patch to be working properly in sandbox~~
- ☐ Update patch to use calculations OR config values instead of hardcoded vals

Progress:

Got unpatched latest develop UE and gNB running on ARA sandbox. Running them on the same machine (Host 020) allowed them to latch together successfully. Had RSRP of -101

Patch does not work properly, gets stuck on RAR reception. Using the same host DOES fix NACK error, but still doesn't work as expected.
The above error has been resolved. The issue was the max RX gain in the gnb.conf. The new output can be seen below, there may still be some issues we will want to iron out.

```
[NR_PHY]   [RAPROC] 423.19 Initiating RA procedure with preamble 1, energy 45.8 dB (I0 274, thres 120), delay 1 start symbol 8 freq index 0
[NR_MAC]   423.19 UE RA-RNTI 0113 TC-RNTI 5b5b: initiating RA procedure
[NR_MAC]   UE 5b5b: Msg3 scheduled at 424.18 (424.6 TDA 2) start 0 RBs 8
[NR_MAC]   UE 5b5b: 424.6 Generating RA-Msg2 DCI, RA RNTI 0x113, state 1, preamble_index(RAPID) 1, timing_offset = 1 (estimated distance 39.1 [m])
[NR_MAC]   424.6 Send RAR to RA-RNTI 0113
[NR_MAC]    424.18 PUSCH with TC_RNTI 0x5b5b received correctly
[MAC]   [RAPROC] Received SDU for CCCH length 6 for UE 5b5b
[RLC]   Activated srb0 for UE 23387
[RLC]   Added srb 1 to UE 23387
[NR_MAC]   Activating scheduling Msg4 for TC_RNTI 0x5b5b (state WAIT_Msg3)
[NR_RRC]   Decoding CCCH: RNTI 5b5b, payload_size 6
[NR_RRC]   [--] (cellID 0, UE ID 1 RNTI 5b5b) Create UE context: CU UE ID 1 DU UE ID 23387 (rnti: 5b5b, random ue id 626a3c9b19000000)
[RRC]   activate SRB 1 of UE 1
[NR_RRC]   [DL] (cellID bc614e, UE ID 1 RNTI 5b5b) Send RRC Setup
[NR_MAC]   UE 5b5b Generate Msg4: feedback at  425.17, payload 225 bytes, next state nrRA_WAIT_Msg4_MsgB_ACK
[NR_MAC]   Adding new UE context with RNTI 0x5b5b
[NR_MAC]    425.17 UE 5b5b: Received Ack of Msg4. CBRA procedure succeeded!
[NR_MAC]   Unexpected ULSCH HARQ PID 2 (have 0) for RNTI 0x5b5b
[NR_MAC]   Unexpected ULSCH HARQ PID 3 (have 1) for RNTI 0x5b5b
[NR_MAC]   Unexpected ULSCH HARQ PID 3 (have 0) for RNTI 0x5b5b
[NR_MAC]   Unexpected ULSCH HARQ PID 0 (have 1) for RNTI 0x5b5b
[NR_MAC]   Unexpected ULSCH HARQ PID 5 (have 4) for RNTI 0x5b5b
[NR_MAC]   Unexpected ULSCH HARQ PID 5 (have 1) for RNTI 0x5b5b
[NR_MAC]   Unexpected ULSCH HARQ PID 7 (have 4) for RNTI 0x5b5b
[NR_MAC]   Unexpected ULSCH HARQ PID 8 (have 6) for RNTI 0x5b5b
[NR_MAC]   Unexpected ULSCH HARQ PID 8 (have 4) for RNTI 0x5b5b
[NR_MAC]   Unexpected ULSCH HARQ PID 10 (have 6) for RNTI 0x5b5b
[NR_RRC]   [UL] (cellID bc614e, UE ID 1 RNTI 5b5b) Received RRCSetupComplete (RRC_CONNECTED reached)
[NGAP]   Selected PLMN in the NG Initial UE Message: MCC 1, MNC 1
[NGAP]   No AMF is associated to the gNB
[NR_MAC]   Unexpected ULSCH HARQ PID 11 (have 9) for RNTI 0x5b5b
[NR_MAC]   Unexpected ULSCH HARQ PID 11 (have 6) for RNTI 0x5b5b
[NR_MAC]   Unexpected ULSCH HARQ PID 12 (have 9) for RNTI 0x5b5b
[NR_MAC]   Unexpected ULSCH HARQ PID 13 (have 9) for RNTI 0x5b5b
[NR_MAC]   Frame.Slot 512.0
UE RNTI 5b5b CU-UE-ID 1 in-sync PH 36 dB PCMAX 20 dBm, average RSRP -100 (10 meas)
UE 5b5b: dlsch_rounds 2/0/0/0, dlsch_errors 0, pucch0_DTX 0, BLER 0.10000 MCS (0) 0
UE 5b5b: ulsch_rounds 21/5/5/5, ulsch_errors 5, ulsch_DTX 6, BLER 0.06144 MCS (0) 0 (Qm 2 deltaMCS 0 dB) NPRB 5  SNR 27.5 dB
```

This is the unpatched gNB output when latching:

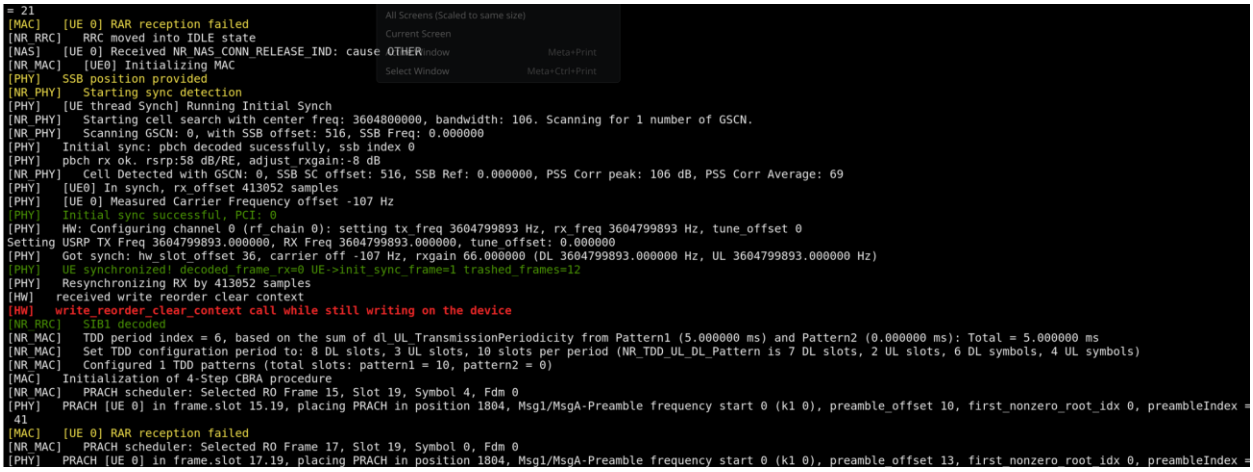
```
sleep...
sleep...
sleep...
[PHY]   Command line parameters for OAI UE: -C 3604800000 -r 106 --numerology 1 --ssb 516 -E
[NR_MAC]   Frame.Slot 384.0

[NR_PHY]   [RAPROC] 393.19 Initiating RA procedure with preamble 45, energy 45.2 dB (I0 275, thres 120), delay 0 start symbol 4 freq index 0
[NR_MAC]   393.19 UE RA-RNTI 010f TC-RNTI ae5b: initiating RA procedure
[NR_MAC]   UE ae5b: Msg3 scheduled at 394.17 (394.7 TDA 3) start 0 RBs 8
[NR_MAC]   UE ae5b: 394.7 Generating RA-Msg2 DCI, RA RNTI 0x10f, state 1, preamble_index(RAPID) 45, timing_offset = 0 (estimated distance 0.0 [m])
[NR_MAC]   394.7 Send RAR to RA-RNTI 010f
[NR_MAC]    394.17 PUSCH with TC_RNTI 0xae5b received correctly
[MAC]   [RAPROC] Received SDU for CCCH length 6 for UE ae5b
[RLC]   Activated srb0 for UE 44635
[RLC]   Added srb 1 to UE 44635
[NR_MAC]   Activating scheduling Msg4 for TC_RNTI 0xae5b (state WAIT_Msg3)
[NR_RRC]   Decoding CCCH: RNTI ae5b, payload_size 6
[NR_RRC]   [--] (cellID 0, UE ID 1 RNTI ae5b) Create UE context: CU UE ID 1 DU UE ID 44635 (rnti: ae5b, random ue id 365b63f377000000)
[RRC]   activate SRB 1 of UE 1
[NR_RRC]   [DL] (cellID bc614e, UE ID 1 RNTI ae5b) Send RRC Setup
[NR_MAC]   UE ae5b Generate Msg4: feedback at  395.17, payload 225 bytes, next state nrRA_WAIT_Msg4_MsgB_ACK
[NR_MAC]    395.17 UE ae5b: Received Ack of Msg4. CBRA procedure succeeded (UE Connected)
[NR_MAC]   Adding new UE context with RNTI 0xae5b
[NR_RRC]   [UL] (cellID bc614e, UE ID 1 RNTI ae5b) Received RRCSetupComplete (RRC_CONNECTED reached)
[NGAP]   Selected PLMN in the NG Initial UE Message: MCC 1, MNC 1
[NGAP]   No AMF is associated to the gNB
[NR_MAC]   Frame.Slot 512.0
UE RNTI ae5b CU-UE-ID 1 in-sync PH 38 dB PCMAX 20 dBm, average RSRP -100 (14 meas)
UE ae5b: dlsch_rounds 3/0/0/0, dlsch_errors 0, pucch0_DTX 0, BLER 0.09000 MCS (0) 0
UE ae5b: ulsch_rounds 138/0/0/0, ulsch_errors 0, ulsch_DTX 0, BLER 0.03138 MCS (0) 5 (Qm 2 deltaMCS 0 dB) NPRB 5  SNR 27.5 dB
UE ae5b: MAC:    TX             34 RX              764 bytes
UE ae5b: LCID 1: TX              3 RX               65 bytes
```

New TODO: Fix HARQ PID bug. This shouldn't be too bad considering how small the changes are. Then we can change the values to be pulled from a config. 8

Notes/Questions:

New UE output for patched version.



Date: 07/08/2025

Plans/TODO:

- ☒ ~~Fix HARQ bug (unsure)~~
- ☒ ~~Prepare for OAI outdoor testing.~~
- ☒ ~~Generate OAI Patch File from fork~~
- ☐ Move values to config file, or dynamically calculate in OAI patch
- ☐ Test srsRAN outdoors (when we get cable)
- ☒ ~~Test OAI Outdoors~~

Progress:

HARQ Bug is strange, I haven't made any changes to anything after Msg3. This bug does not seem to directly affect connectivity. HARQ happens after msg4 ack. Maybe this has to do with TDA?

Looking through the logs, It appears that Msg2 is being sent in slot 6 and Msg3 is being sent in slot 18 as expected.

OAI Has been prepared for outdoor testing. It appears that it should work as expected.

Patch has been generated as an alternative to using my github fork. This patch is built for 2025_W27 (Current develop branch of 07/08/2025).

Notes/Questions:

Generating a patch that can be applied is relatively easy. Clone the fork. Run

"git remote set-url upstream https://gitlab.eurecom.fr/oai/openairinterface5g.git"
"git diff upstream/<week 27 tag> origin/develop" <- or something similar to generate a diff comparing the fork to the original fork.

Date: 07/09/2025

Plans/TODO:

- ☐ Move values to config file, or dynamically calculate in OAI patch
- ☐ Test srsRAN outdoors (when we get cable)
- ☐ Test OAI Outdoors (throughput)
- ~~☐ Set up Ara JumpBox for SSH into containers~~

Progress:

Created a Key to allow me to ssh into jumpbox. Still need to test SSHing into containers.

After Joshua finishes meetings, we will test throughput on outdoor OAI (it should be working as expected).

To pull the values from the config we will need to modify RRC_nr_paramsvalues.h in /openair2/GNB_APP
I think a good approach to pull from config is choosing the Msg2 slot and K2 value.
Then we can do an assert to make sure that it occurs in a DL and UL slot respectively.
Not sure if this will work… Only because right now msg2 is scheduled in a strange way that just works but im not sure how.

Notes/Questions:

Note to self. Ara key is stored in /home/tyler under *ara* (private key) and *ara.pub* (Public key).

Command to ssh into jumpbox: ssh -i ara tbibus_IASTATE@jbox.arawireless.org

Date: 07/10/2025

Plans/TODO:

- ☐ Move values to config file, or dynamically calculate in OAI patch
- ☐ Test srsRAN outdoors (when we get cable)
- ~~☐ Test OAI Outdoors (throughput)~~
- ~~☐ Successfully use Jumpbox~~

Progress:

Using jumpbox was a little confusing at first, only because I was attempting to set ssh settings on the jumpbox and not the server.

We ran into an issue with OAI where when putting stress on the system we couldn't achieve throughput much higher than 4 mbps. This was related to the HARQ problem. I discovered that TDA index 2 was missing from the patch (oops) and readded it. We now have clean traces and are ready to test more outdoor throughput (it should work though).

Notes/Questions:

To ssh into containers, set the ssh settings on the container itself and NOT jumpbox!

Date: 07/11/2025

Plans/TODO:

- ☒ ~~Test throughput with fixed OAI~~
- ☐ Create Poster for presentation.
- ☒ ~~Fill out Task Report~~
- ☐ Test srsRAN outdoors (waiting on cable)
- ☐ Move OAI K2 Value to config. (Msg2 will automatically reschedule based on K2)

Progress:

HARQ issue resolved, need to test throughput, but I am 99% certain that it will work as expected once Joshua and I test it.

Filled out Task Report sent from Selim for first half task progress.

Got Poster Template, as well as some initial information. Will be developing the poster to be based on my srsRAN project.

Notes/Questions:

Week 07/14-18/2025

Date: 07/14/2025

Plans/TODO:

- ☒ ~~Create srsRAN Poster~~
- ☒ ~~Create abstract for srsRAN Poster Presentation~~
- ☐ Test OAI Throughput outdoors
- ☐ Test srsRAN outdoors (waiting for cable)
- ☐ Move k2 and Msg3 slot values to config file (OAI)

Progress:

Created an abstract that tells the story of the problem, method, solution, results of the srsRAN project.

Copied template for poster, ran into issue editing it on laptop. Adobe acrobat is the best option but runs painfully slow on laptop. Going home early to work on it on my more powerful desktop.

Notes/Questions:

Basically the last steps for all the projects just require help with Joshua and/or additional hardware. They are also verification tests that are 99% likely to succeed.

Date: 07/15/2025

Plans/TODO:

- ☒ ~~Finish srsRAN Poster~~
- ☒ ~~Finish srsRAN Abstract~~
- ☐ Test OAI Outdoor Throughput
- ☐ Move Msg3 and k2 values to config (OAI, Msg2 is determined by k2 and msg3)
- ☐ Test srsRAN outdoors (waiting for cable)

Progress:

Finished Poster with feedback from Joshua

Finished srsRAN Abstract from Joshua

Submitted poster and abstract for presentation (July 31st, 2-4:30, SIC atrium)

Notes/Questions:

Poster should be 36x48 or smaller

Date: 07/16/2025

Plans/TODO:

- ☐ Move Msg3 and k2 to throughput
- ☐ Test OAI Throughput
- ☐ Test srsRAN Outdoors (waiting for cable)

Progress:

Attempted to test OAI throughput. While I was able to latch with no HARQ errors, I couldn't route to the core and test throughput.

Moved hardware from 91 to Coover 3038 for Reshal.

Notes/Questions:

Date: 07/17/2025

Plans/TODO:

- ☐ Move Msg3 and k2 to throughput
- ☐ Test OAI Throughput
- ☐ Test srsRAN Outdoors (waiting for cable)

Progress:

Discovered that Msg2 is determined by Msg3 schedule AND k2 + Delta. This means that in the config we will need to choose Msg3 and k2, and not Msg2 and k2. This is a little counterintuitive but will work the same for our purpose.

Found that it is difficult or likely impossible to add additional variables to the NR_ServingCellConfigCommon_t struct
Meaning I will need to find a way to load them another way. Maybe try another struct? There is quite literally NO definition for the above struct.

Notes/Questions:

Reading values from config is a little confusing. But I believe I know the file to put it in, I am just not sure If I am reading it correctly or not.

Date: 07/18/2025

Plans/TODO:

- ☐ Move Msg3 and k2 to throughput
- ☐ Test OAI Throughput
- ☐ Test srsRAN Outdoors (waiting for cable)

Progress:

Trying to add the values to the config is very difficult, Ive tried a few different approaches (i.e. Attempting to add it to the RRC config file, but the SCC struct doesn't have a definition I can edit. I am trying instead to do it through the nr_mac_config_t struct, but it is very confusing how they get the values from the config into the object. I am attempting to do it in the same way that the Antenna values are pulled.)

Notes/Questions:

Week 07/21-25/2025

Date: 07/21/2025

Plans/TODO:

- ☐ Move Msg3 and k2 to config

- ☐ Test OAI Throughput
- ☐ Test srsRAN Outdoors (Nearly Ready)

Progress:

Got the cable for srsRAN, waiting for more info from Joshua, but we should be able to test whenever the core is up and running.

OAI Config values are continuing to be frustrating. I modified the asn1 values, which allowed the structs to have the new variables, but it breaks compilation by creating “File not Found” Errors. I believe that because of the strict nature of the standardized variables, modifying it causes some bad errors.
The new approach will be modifying a OAI specific structure implementation that is reachable in both msg3_retransmission and TDA index 3. This struct should also be modifiable from the config file.

Moved a few boxes to 3038 for Reshal again.

Notes/Questions:

Found a structure that might work, gNB_MAC_INST, and by modifying that ns well as nr_mac_config_t I may be able to pull from config properly.

Week 08/04/2025 & 08/11/2025

Plans/TODO:

- ☐ ~~Move Msg3 and k2 to config~~
- ☐ ~~Test OAI Throughput~~
- ☐ ~~Test srsRAN Outdoors (Nearly Ready)~~
- ☐ ~~Create Documentation for srsRAN Experiments (?)~~
- ☐ ~~Create Documentation on OAI Patch~~
- ☐ ~~Create documentation for mender (?)~~
- ☐ ~~Compile documentation (for ARA Summer program for future reference)~~
- ☐ ~~Create PowerPoint presentation for end-of-summer REU Presentation.~~

Progress:

We have successfully tested srsRAN Outdoors to great success with a stable connection. More testing is required for exact maximum range, connectivity, etc.

OAI Testing has shown that the new release works as expected with proper scheduling.

I have found out how to add values to the config file (see OAI Section). I have had 2 approaches, defining msg2_slot and k2_msg3, and defining msg2_slot and msg3_slot. I believe the second approach makes more sense to the end user. If they are left undefined it uses the old OAI method for calculating.

Documentation has been created and can be found on GitHub:
https://github.com/Tyler-Bibus/araSummer25-Documentation.git

Final Comments

I am grateful to the ARA team for this opportunity. I have learned so much, both in software development and my own professional experience. I with the ARA team the best going forward with all their projects. A Special thanks to Joshua, I wouldn't have been able to complete anywhere near as much without your guidance.