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# OpenAirInterface RAN Project

OAI Working Practices, Development Process, and Roadmap

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Robert Schmidt (OSA)

14 November 2023



# Outline

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Highlights of new features, current KPIs

O-RAN and OAI

Roadmap and Releases

CI/CD



# New features (gNB) in 2023

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- ▶ UL 2x2 MIMO
- ▶ FR2 Basic SA with OAI UE
- ▶ Support for Nvidia Aerial SDK L1 Offload
- ▶ 3GPP F1 and E1: work on internal data organization to use F1 and E1 logic
  - ▶ Multiple reconfigurations
  - ▶ Reestablishments
  - ▶ Multiple DUs and CU-UPs
- ▶ 7.2 through OSC FHI library, E release
- ▶ Merge of E2 agent with KPM v2.03/v3.0 and RC v1.00



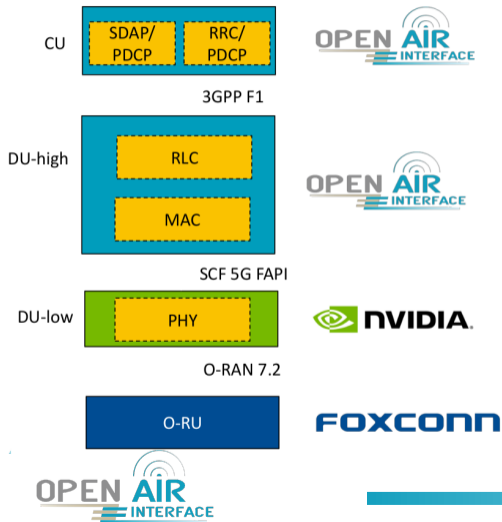
# New features (UE) in 2023

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- ▶ UL/DL 2x2 MIMO
  - ▶ Ongoing testing with 3<sup>rd</sup>-party gNB
  - ▶ Implementation of Sidelink
  - ▶ Reconfiguration with sync and measurements
  - ▶ Improvements in multi-threading
  - ▶ Improved testing through IQPlayer
- ▶ Code cleanup:
    - ▶ MAC/PHY separation (UE “FAPI”)
    - ▶ PUCCH handling
    - ▶ Reserved MCS for retransmission
    - ▶ Search space/CORESET handling
    - ▶ RRC State handling
    - ▶ BWP handling



# Nvidia Aerial Research Cloud (ARC)



- ▶ Nvidia Aerial is an inline L1 accelerator running on
  - ▶ GPU (A100) and smart NIC (CX6) or
  - ▶ converged accelerator (A100X or AX800)
- ▶ DU-high (Layer 2), CU, and core from OpenAirInterface
- ▶ Interface realized using 5G FAPI defined by Small Cell Forum (Traces can be analyzed in Wireshark)
- ▶ March 2023: initial release, early adopters (e.g. Northeastern)
- ▶ Nov 2023: Aerial 23-2 integration into develop

# OAI gNB performance (Oct. 2023)

## gNB – Max Downlink Throughput, Band n41, TDD: DDDFU

DL		Bandwidth (MHz)/Number of PRBs @ 30kHz												
(Mbps)		5/11	10/24	15/38	20/51	25/65	30/78	40/106	50/133	60/162	70/189	80/217	90/245	100/273
Layers	1				<b>72</b>			<b>152</b>		<b>233</b>		<b>310</b>		<b>400</b>
	2				<b>143</b>			<b>304</b>		<b>466</b>		<b>622</b>		<b>800</b>
	4													

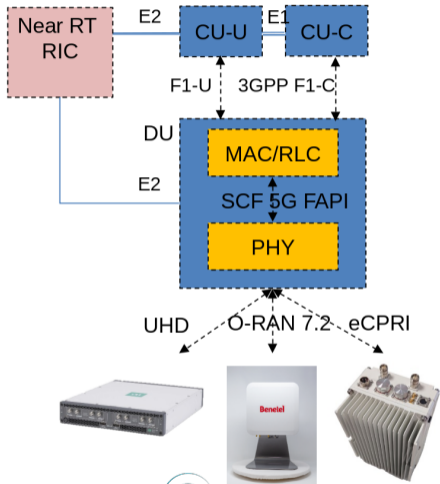
## gNB – Max Uplink Throughput, Band n41, TDD: DDFUU

UL		Bandwidth (MHz)/Number of PRBs @ 30kHz												
(Mbps)		5/11	10/24	15/38	20/51	25/65	30/78	40/106	50/133	60/162	70/189	80/217	90/245	100/273
Layers	1				<b>39</b>			<b>81</b>		<b>123</b>		<b>80</b>		<b>101</b>
	2				<b>65</b>			<b>154</b>		<b>175</b>		<b>140</b>		<b>120</b>
	4													

(Measurements in AllBeSmart lab, gNB/N310+---tune-offset, UE/Quectel RM500Q-GL)



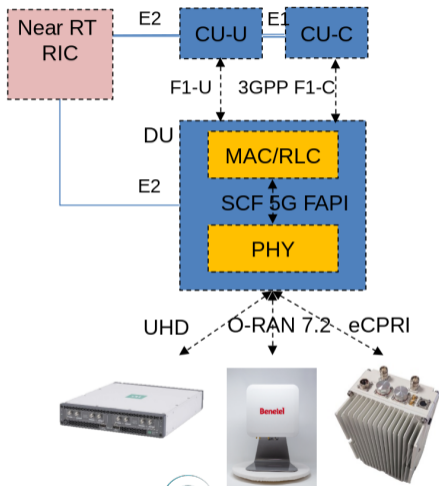
# OpenAirInterface and O-RAN I



- ▶ **O1**
  - ▶ Integration with ONAP-based SMO (see demo)
- ▶ **E2: multiple options**
  - ▶ FlexRIC
  - ▶ O-RAN RIC (see demo)
- ▶ **F1-C and F1-U**
  - ▶ Interop.: OAI DU with Accelleran CU
  - ▶ Multiple DUs per CU
- ▶ **E1**
  - ▶ Multiple OAI CU-UPs per OAI CU-CP



# OpenAirInterface and O-RAN II



## ► 5G FAPI

- today all\* L1 procedures compliant with SCF 5G FAPI 222.10.02
- Interop.: Nvidia Aerial SDK
- 5G nFAPI

## ► Fronthaul

- UHD with USRP (split 8)
- eCPRI with AW2S (split 8)
- O-RAN 7.2 CUS-plane (with OSC xRAN lib E, LiteOn)
- Interop.: other RRUs (Benetel, Foxconn, Mavenir) ongoing





# Roadmap

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## Q4 2023

- ▶ O-RAN 7.2 Fronthaul (Rel. E)
- ▶ F1 Handover
- ▶ LDPC enc/dec offload on T2
- ▶ Multiple-DUs and CU-UPs
- ▶ Multiple RUs per DU
- ▶ OAI UE Initial Access with 3rd Party gNB
- ▶ FR2 Basic SA with OAI UE
- ▶ FR2 Basic NSA Interop with COTS UE

## Q1 2024

- ▶ Support for O-RAN 7.2 FH Releases F
- ▶ OAI UE Interoperability with 3rd Party gNB
- ▶ DL MIMO: 4 Layers
- ▶ QoS Aware Scheduler
- ▶ Sidelink
- ▶ NRPP Support in gNB
- ▶ 2-step RACH



# Roadmap

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## Q2 2024

- ▶ Beamforming Procedures for FR2 (NSA and SA)
- ▶ Xn Handover Procedures
- ▶ Support for short-data Transmission (Rel.17)
- ▶ Support of 5G RAN Slicing

## Q3 2024

- ▶ Multi-UE Bandwith Part Handling



# Release process

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## Release v2.0

- ▶ First official 5G release
- ▶ Branch master updated:  
5G SA, NSA for gNB, UE

## Release v2.1

- ▶ F1 handover
- ▶ O-RAN 7.2 FHI, E release
- ▶ Nvidia Aerial support

## Release v2.2

- ▶ MIMO 4x4 DL
- ▶ 7.2 FH F release
- ▶ Sidelink support

⇒ Releases planned every 3-4 months



# CI/CD: Review and Workflow

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## Human Part

- ▶ Contributor has to sign CLA
- ▶ Senior OAI developer “volunteers” for review
- ▶ Every week: 30min slot in dev meeting to discuss merge status
- ▶ Public access to any build/test logs
- ▶ Documentation: `doc/TESTBenches.md`

## Automated Part

- ▶ Apply label in MR (Doc, Build, 4G, 5G)
- ▶ Jenkins pipeline is triggered
  - ▶ Container image build
  - ▶ Static analysis
  - ▶ Testing (next slide)
- ▶ No automatic acceptance of MRs: integration branch
- ▶ Images on docker hub published by `oaisoftwarealliance.org`



# CI/CD: Review and Workflow

## chore(ci): adding back part of old IF4.5 LTE legacy tests

Open Raphael Defosseux requested to merge ci-adding-back-lte-lf4-5-t into devLap 21 hours ago

Overview 2 Commits 3 Pipelines 1 Changes 8

1 unresolved thread

- Only one bandwidth will be tested per modulation (FDD/TDD)
- Will clean-up scenarios and conf files that won't be used any more

First few commits, I need a private image. Hence `BUILD-ONLY` label.



Pipeline #37964 passed for 4deec5bc on ci-adding-back-lte-... 20 hours ago

Approve Approval is optional

Ready to merge!

Delete source branch  Edit commit message

1 commit and 1 merge commit will be added to devLap.

Merge

### Activity

Sort or filter

- Raphael Defosseux added `BUILD-ONLY` label 21 hours ago
- Raphael Defosseux requested review from @Bath 21 hours ago
- Raphael Defosseux assigned to @defosseux 21 hours ago

OAI CI JenkinsBot @jenkinsbot - 20 hours ago

OAI RAN-Container-Parent build (5212): passed (https://jenkins-oai.eurecom.fr/job/RAN-Container-Parent/5212/)

Dhanuja Elizabeth Thomas @beth started a thread on the diff 50 minutes ago

ci-scripts/conf\_files/roc.band40.tml.25PRB.FairScheduler.usrb210.conf

```
1 - Active_eREs = { "eNB_Eurcom_LTEB40";
```

Dhanuja Elizabeth Thomas @beth - 50 minutes ago

It would be nice if you can change the file name based on the naming convention given in the README inside conf\_files:  
[<sa>]nsa->[]band[.u|prb].[]conf

Edited 56 minutes ago by Dhanuja Elizabeth Thomas

Reply... Resolve thread



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Dhanuja Elizabeth Thomas @beth started a thread on the diff 59 minutes ago

ci-scripts/conf\_files/roc.band40.tml.25PRB.FairScheduler.usrbp210.conf

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1 - Active_eRts = { "eNB_Eurcom_LTEBng";
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Dhanuja Elizabeth Thomas @beth 59 minutes ago  
It would be nice if you can change the file name based on the naming convention given in the README inside conf\_files:  
[<sa>]nsa->]band[.u[prb].1.conf

Edited 56 minutes ago by Dhanuja Elizabeth Thomas

Resolve thread



## Jenkins

Dashboard > RAN-Container-Parent > #5212

Status

Changes

Console Output

View Build Information

Polling Log

Parameters

Timings

Git Build Data

Clouds

Pipeline Steps

Previous Build

Next Build

Build #5212 (Jun 12, 2023, 12:43:30 PM)

Triggered by GitLab Merge Request #2159: oai/ci-adding-back-lte-lf4-5-tests => develop

- Build Artifacts
  - test\_results-RAN-cppcheck.html 8.37 KB view
  - test\_results-RAN-RHEL8-Cluster-Image-Builder.html 12.51 KB view
  - test\_results-RAN-Ubuntu18-Image-Builder.html 12.68 KB view

Triggered by GitLab Webhook

This run spent:

- 4.7 sec waiting
- 15 min build duration
- 15 min total from scheduled to completion.

Revision: f09f8ac1422e60295401027d7f78121bb6fcb2af7  
Repository: https://gitlab.eurecom.fr/oai/openairinterface5g.git  
• refs/remotes/origin/develop

# CI/CD: Review and Workflow

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Approve Approval is optional

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```
[<sa|nsa>|].band[.u|prb].l.l.conf
```

Edited 56 minutes ago by Dhanuja Elizabeth Thomas

Reply...

Resolve thread



## Jenkins

Dashboard > RAN-Container-Parent > #5212

Status

Changes

Console Output

View Build Information

Polling Log

Parameters

Timings

Git Build Data

Configure Ocean

Pipeline Steps

Previous Build

Next Build

Build #5212 (Jun 12, 2023, 12:43:30 PM)

Triggered by GitLab Merge Request #2151: ci(0)-adding-back-lte-lf4-5-tests => develop



Build Artifacts

- test\_results-RAN-cpccheck.html 8.37 KB view
- test\_results-RAN-RHEL8-Cluster-Image-Builder.html 12.51 KB view
- test\_results-RAN-Ubuntu18-Image-Builder.html 12.68 KB view



Triggered by GitLab Webhook



This run of job

- 4:20 min waiting
- 1:00 min build duration
- 1:00 min total from scheduled to completion.



Revision: f0998ac1422e60295401027d78121bb6bcb2af

Repository: https://gitlab.eurecom.fr/oai/openairinterface5ggit

https://remotes/origin/develop

### Job Summary - Job: RAN-Ubuntu18-Image-Builder - Build-ID: 4840

Build Step	Time (min)	Status	URL
git	00:00:00	OK	https://gitlab.eurecom.fr/oai/openairinterface5ggit
Job Trigger	00:00:00	OK	https://jenkins-oai.eurecom.fr/job/RAN-Container-Parent/5212/
Source Control	00:00:00	OK	https://gitlab.eurecom.fr/oai/openairinterface5ggit
Source Control Message	00:00:00	OK	https://gitlab.eurecom.fr/oai/openairinterface5ggit
Target Branch	00:00:00	OK	develop

License and Formatting Checks

Test Summary for xml\_files/formatting\_check.xml

Step Name	Test ID	Test Name	Test Status	Test Message
--- By Run #8 ---				
48.4	000000	License and Formatting Checks	OK	Format Passed
48.4	000000	License and Formatting Checks	OK	Header Check Dependency
48.4	000000	License and Formatting Checks	OK	File with GNU GPL License
48.4	000000	License and Formatting Checks	OK	File with SPDX license

Final Test Status

Final Test Status

End of Job report - Copyright © 2013 Sun Microsystems. All Rights Reserved.

# CI/CD: Status and Roadmap

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## Current tests in CI

- ▶ Build: x86/ARM
- ▶ USRP-based, COTS UE (4G/5G)
- ▶ AW2S-based with up to 10 UEs (5G)
- ▶ OAI-UE with OAI gNB OTA (4G, 5G)
- ▶ RFsim (5G: TDD/FDD, E1+F1, ...)
- ▶ Physical simulators
- ▶ 4G/5G L2sim

## Future

- ▶ Using sanitizers in CI
- ▶ More UEs
- ▶ O-RAN 7.2 FH
- ▶ Aerial Inline Accelerator, other accelerators
- ▶ UE tests with 3<sup>rd</sup>-party gNB





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**Thank you for your attention.  
Do you have questions? → Q&A**

Florian Kaltenberger ([florian.kaltenberger@eurecom.fr](mailto:florian.kaltenberger@eurecom.fr))  
Robert Schmidt ([robert.schmidt@openairinterface.org](mailto:robert.schmidt@openairinterface.org))

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# O-RAN 7.2 Fronthaul with T2

- ▶ ORAN 7.2 fronthaul split using OSC fronthaul interface library (FHI, E release)
- ▶ AMD T2 Lookaside Accelerator card
- ▶ 3GPP F1 midhaul split between OAI O-CU/O-DU
- ▶ LITEON O-RU at n78 (3.7 GHz). 100MHz BW. TDD 2.5ms DDDSU

