6G – The first generation with an AI air interface?

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Content

A short walk down 3GPP memory lane

The drive of new generations– a 3GPP PHY perspective

GPRS

The first
packet
switched
data service

EDGE

WCDMA

HSPA

The first true
high-speed
experience

OFDM
MIMO
Wider bandwidths

Advanced MIMO
New frequency ranges

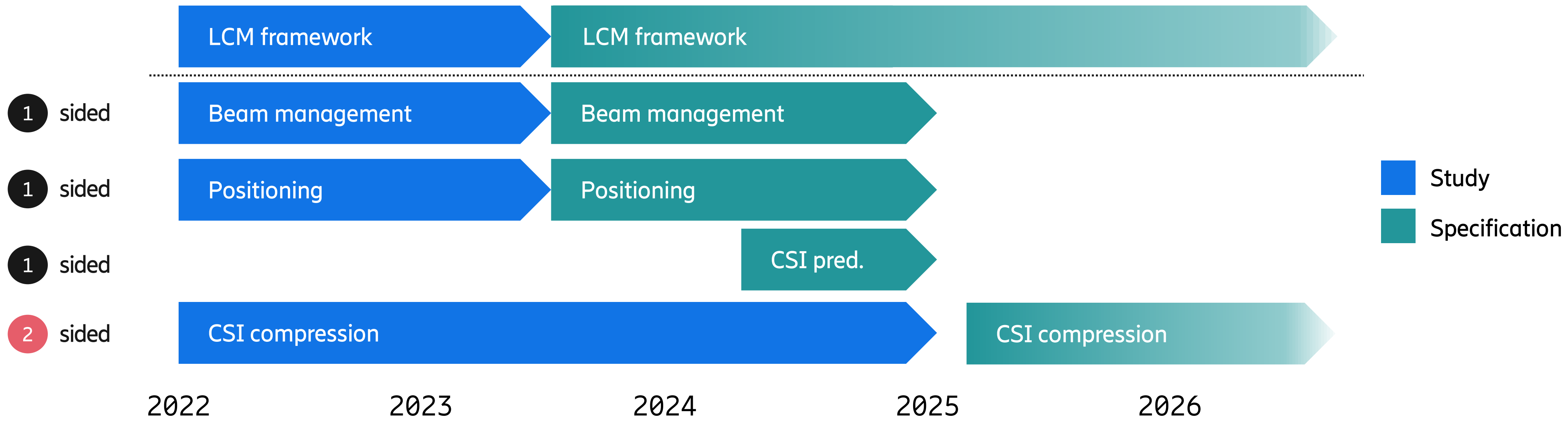
Start of journey towards
an AI air interface

Joint communication and sensing
New frequency ranges
An AI air interface ?
…

Starting the AI air interface journey - 5G Advanced

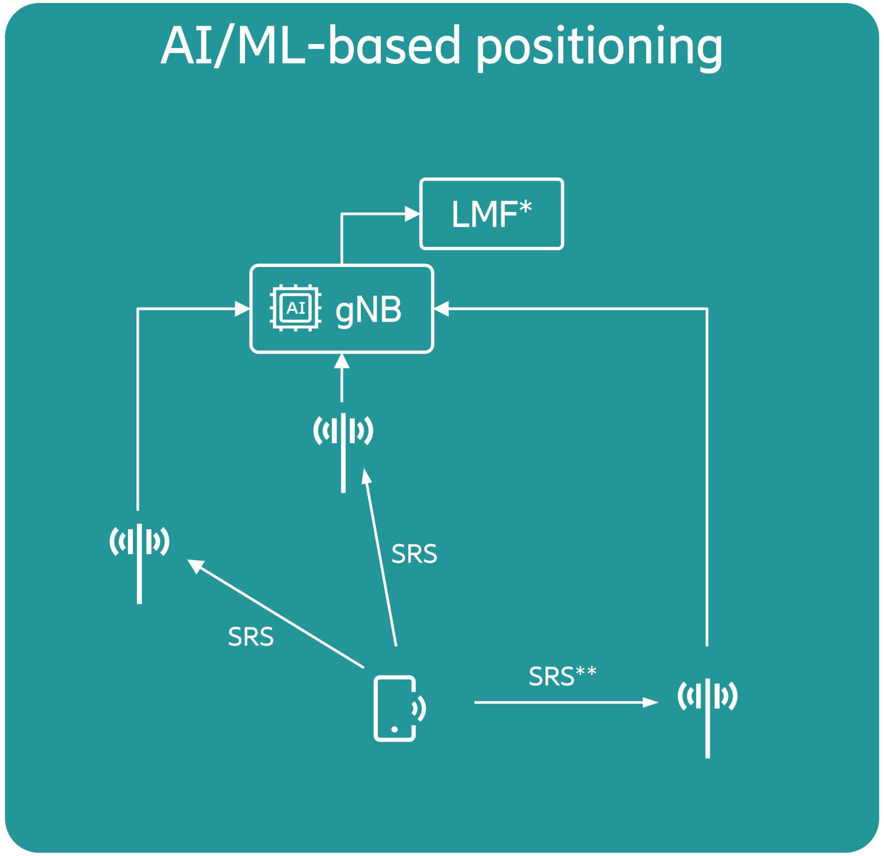
- In 2022 [3], 3GPP set out to start the AI air interface journey by a feasibility study spanning three use cases and a supporting framework (including life-cycle management, LCM, components)
- The journey that started in mid 2022 is now targeted for finalization by the end of Dec 2026

➢ Standardization has been a challenge, specifically for the 2-sided use case (a distributed AI model between base station and UE) with major components still being discussed



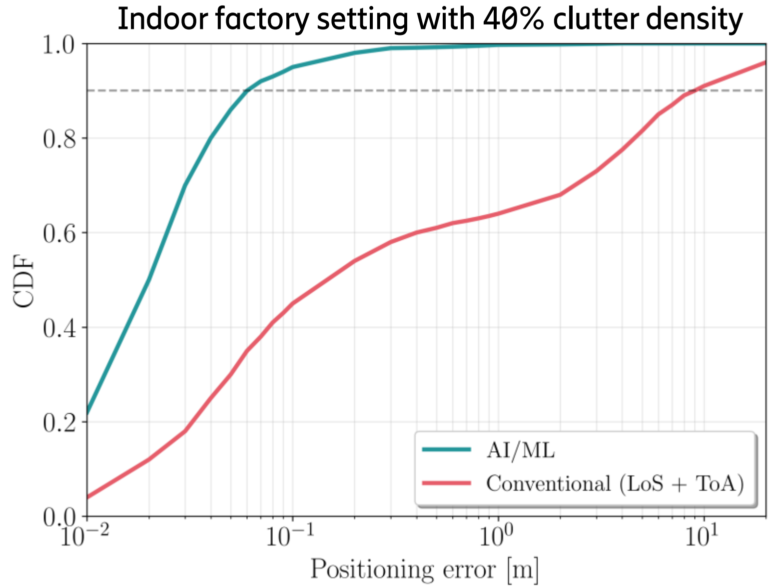
Starting the AI air interface journey – 5G Advanced

Use cases – Positioning



* Location management function
** Sounding reference signal

- One sided model (AI in UE, LMF or base station)
- In challenging environments: >100x more accurate than legacy methods [3]

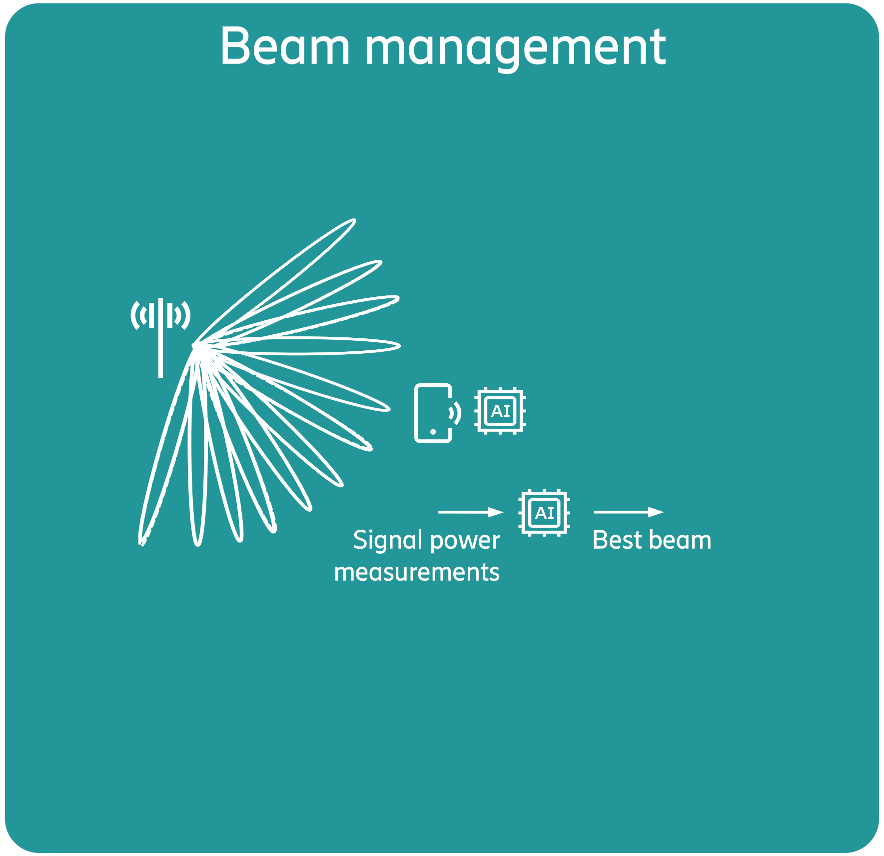


➢ AI/ML can be a performance game-changer!

[4] R1-2302335, "Evaluation of AI/ML for Positioning Accuracy Enhancement," Ericsson, 3GPP TSG-RAN WG1 #112b, April 2023.

Starting the AI air interface journey – 5G Advanced

Use cases – Beam management



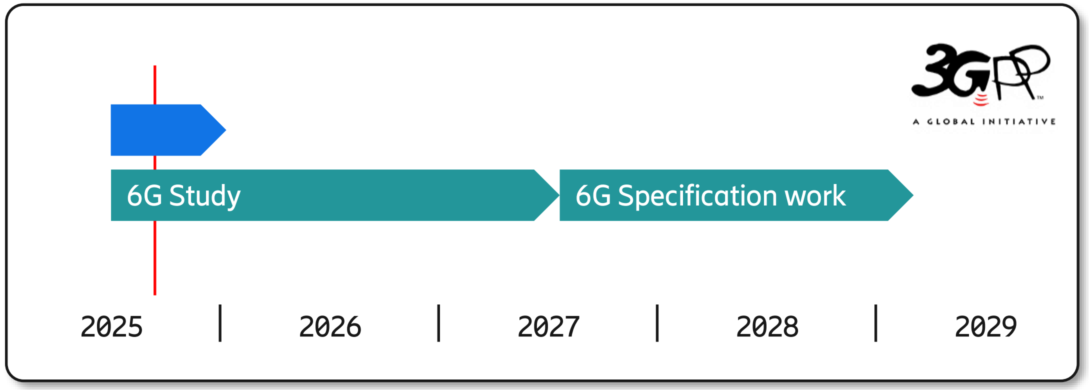
- One sided model (AI in UE or base station)
- Temporal and spatial prediction
- +5%~10% downlink throughput vs. 3GPP exhaustive search benchmark
- But, limited gains seen vs. advanced beam management solutions found in Ericsson's products [5]

➢ Comparing against high-quality benchmarks is essential to draw the right conclusions

[5] R1-2304749, "Evaluation of AIML for beam management", Ericsson, 3GPP TSG-RAN WG1 #113, May 2023.

The journey continues – 6G
The role of AI in the air interface

- The work towards the 6G air interface started in Aug 2025
- A first round of AI use case discussions will happen until end of 2025 ( )



➢ 3GPP agreed in the first 6G meeting on the principle that there will always be non-AI/ML functionality to fall back to

(8) AI/ML for 6GR and Radio Access Network, leveraging 5G AI/ML framework, as appropriate [See TR38.843] [RAN1, RAN2, RAN3, RAN4]
  a) Identify Use Case(s) of interest (either existing or new) with compelling trade-off between e.g., performance, complexity, etc…
  Coordinated discussion needs to be ensured with related design areas, where needed (e.g., MIMO, Mobility, etc…)

  NOTE: lead WG depends on the use case.

  b) AI/ML framework: Extensible AI/ML enablers based on the identified Use Case(s), including
    i. LCM procedures [RAN2, RAN1, RAN3, RAN4]
    ii. Data collection and data management, in coordination with SA WGs [RAN2, RAN3, RAN1]

Note: NW for AI is assumed to be covered by new services

6GR and RAN design shall ensure that the 6G System can also operate without AI/ML

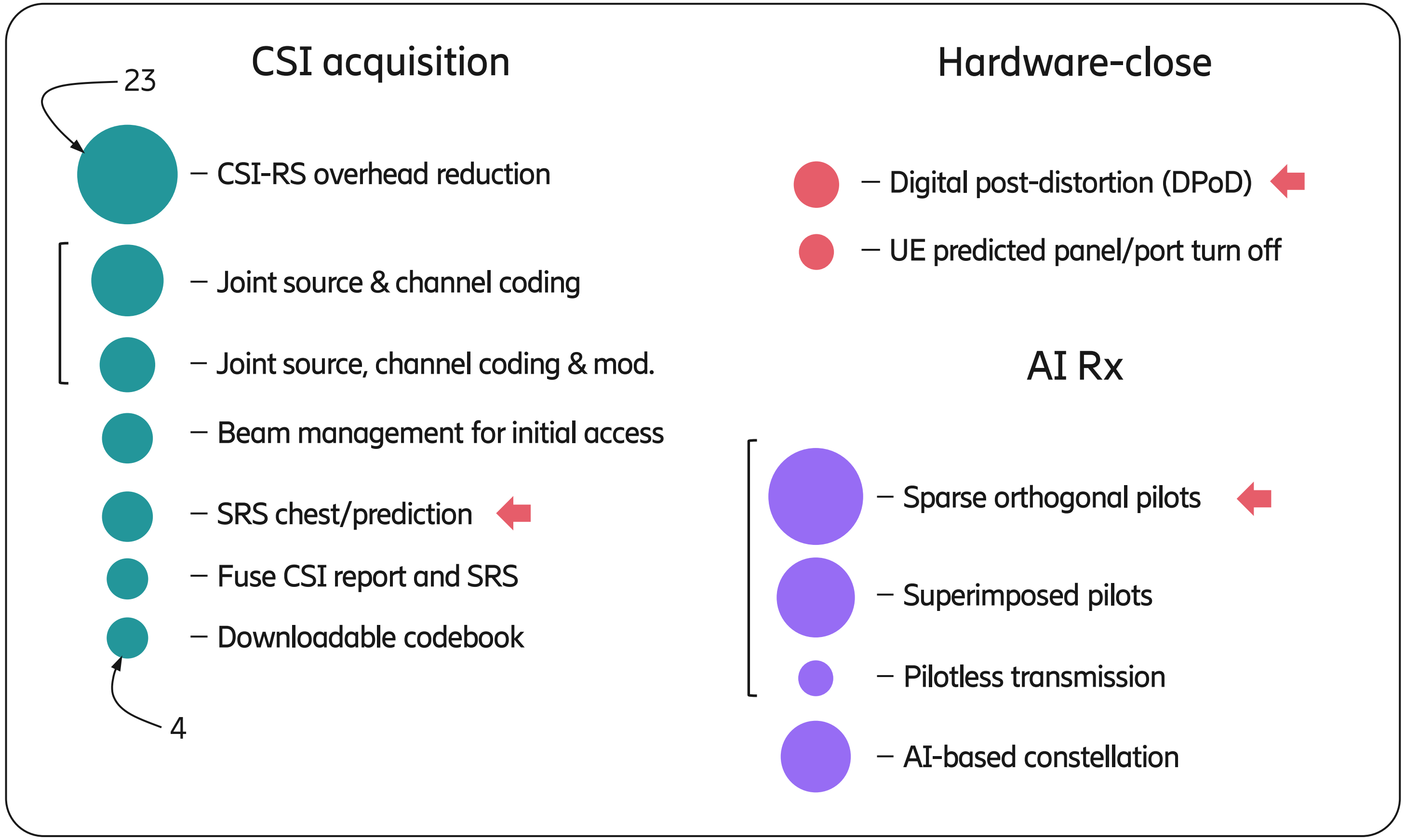
[9] RP-251881, "Study on 6G Radio", 3GPP TSG-RAN #108, June 2025

The journey continues – 6G

Uses cases under consideration

- 30+ new 6G use cases considered
- 5G use cases likely also supported with extensions

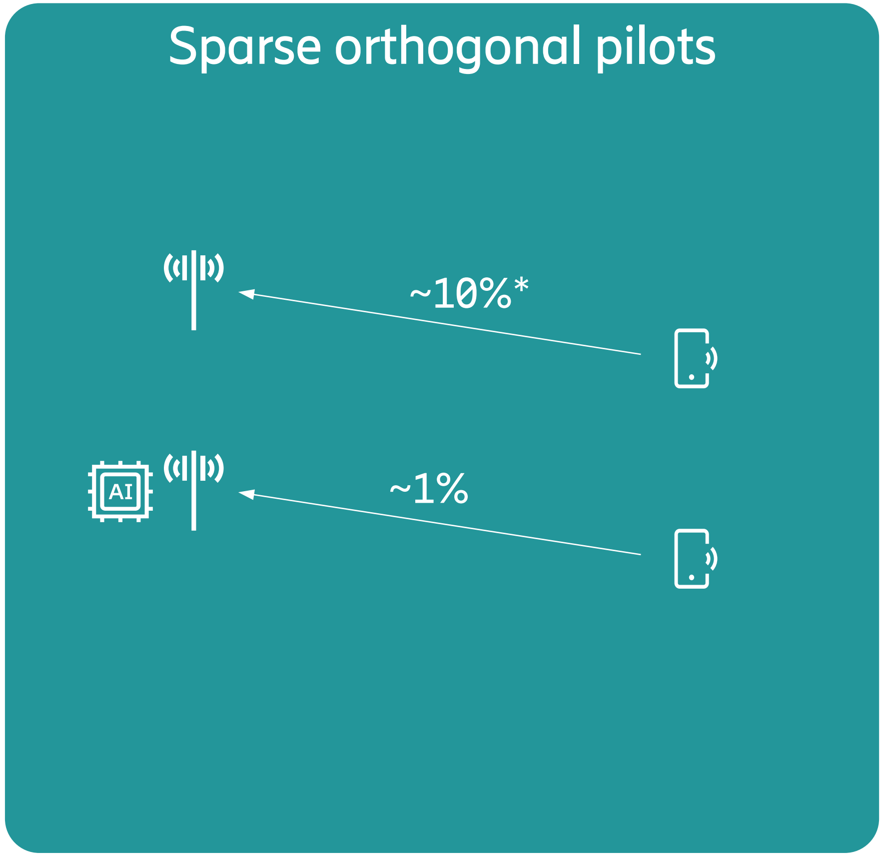
➢ Currently a scattered industry in ambition level and on the preferred 6G air interface functionalities



The 13 most popular shown based on 3GPP TSG-RAN1#122 input*

* Support from at least 3 companies out of the roughly 50 active in the 6G discussions

The journey continues – 6G
Use case – Sparse orthogonal pilots



~10% is for up to 2 layers, but the overhead could be up to ~30%

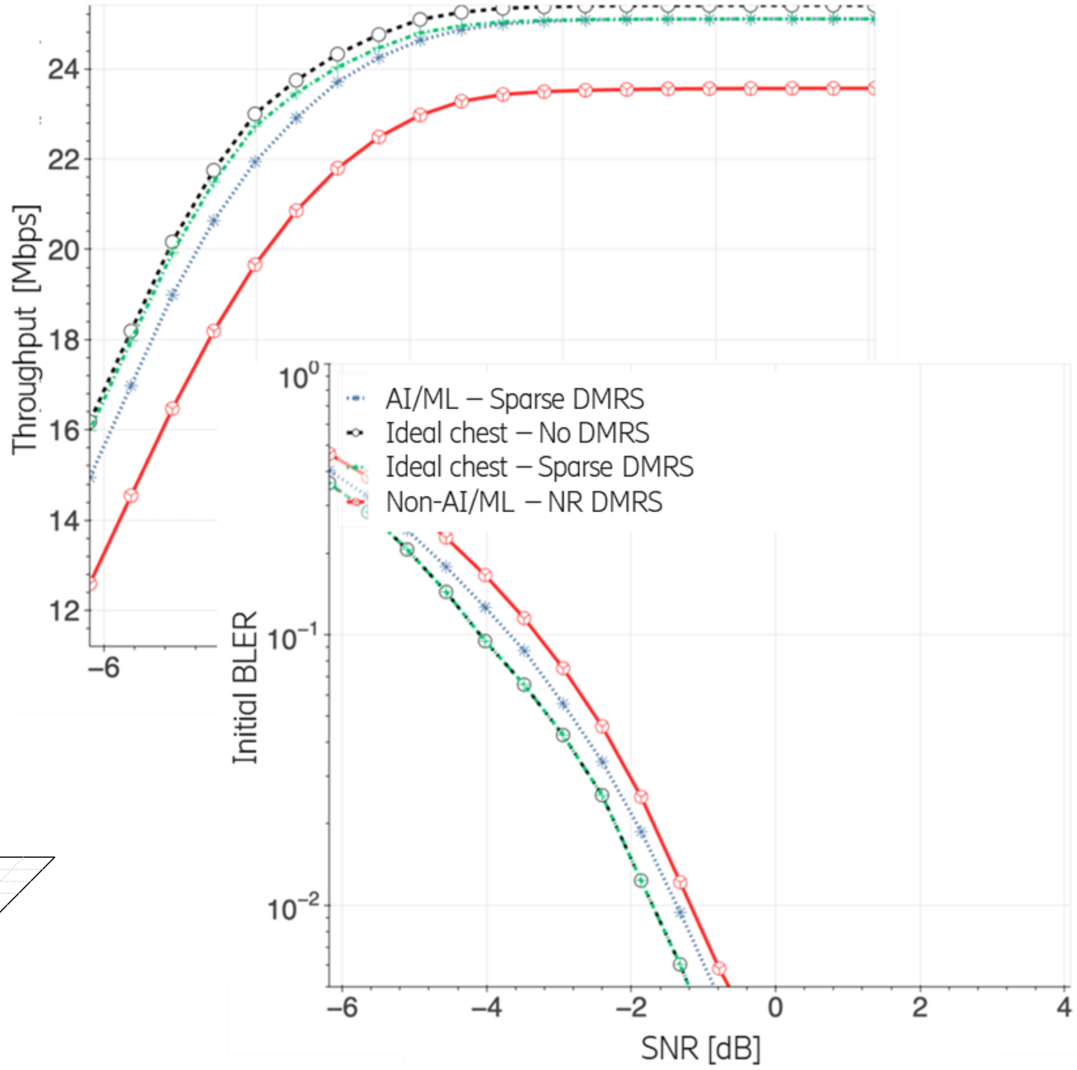
- One sided model (AI in UE or base station)
- The reference signals could constitute a large overhead in NR air interface, specifically when #ports/layers grow
- With AI/ML e.g. making use of both reference signal and data symbols, the overhead can be substantially reduced while maintaining link performance

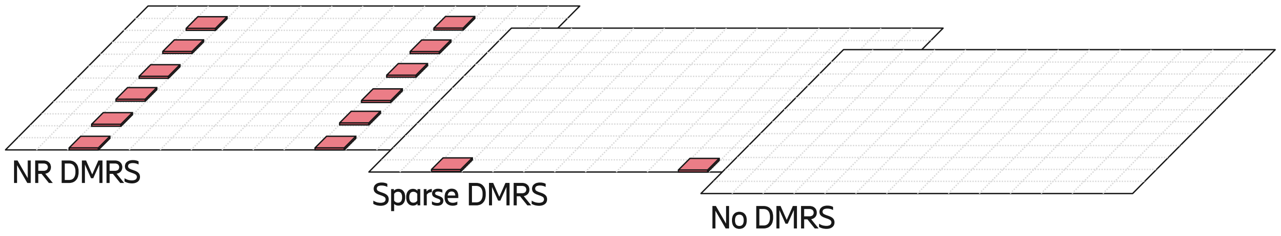
The journey continues – 6G

Use case – Sparse orthogonal pilots

- AI/ML does not only improve the link performance (BLER) but also improved throughput due to the lower overhead
- Superimposed pilots and pilotless transmission are also considered with higher system impact but limited additional performance potential (compared to "no DMRS")

➢ Use cases with meaningful gains that justify the system complexity should be prioritized

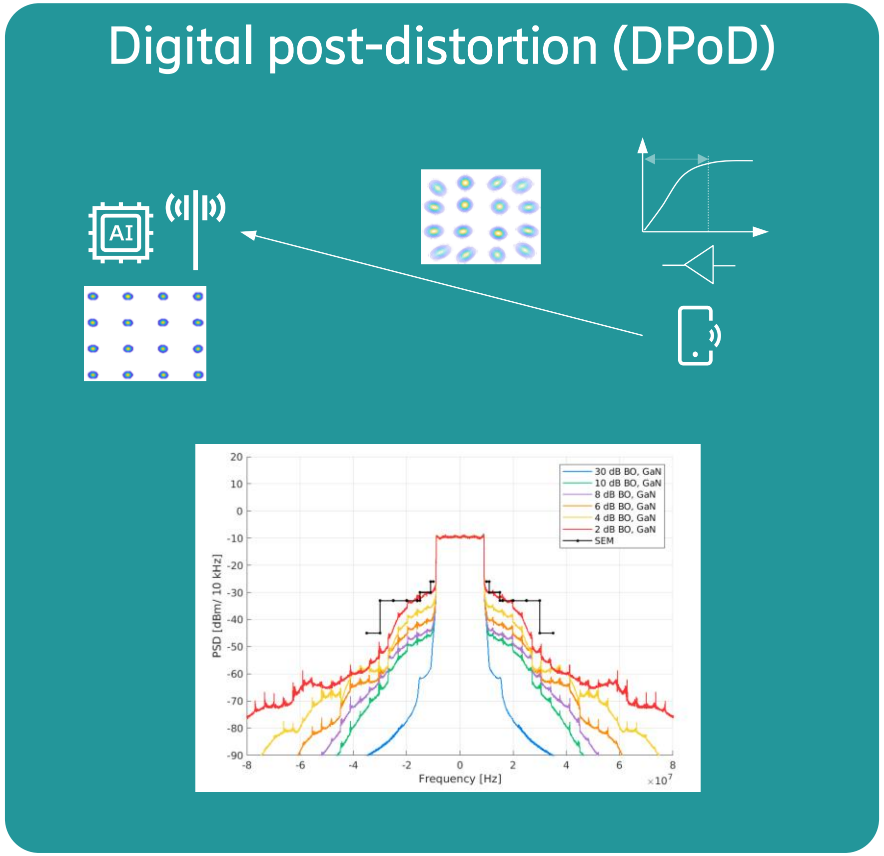




DMRS – Demodulation reference signal

The journey continues – 6G

Use case – Digital post-distortion

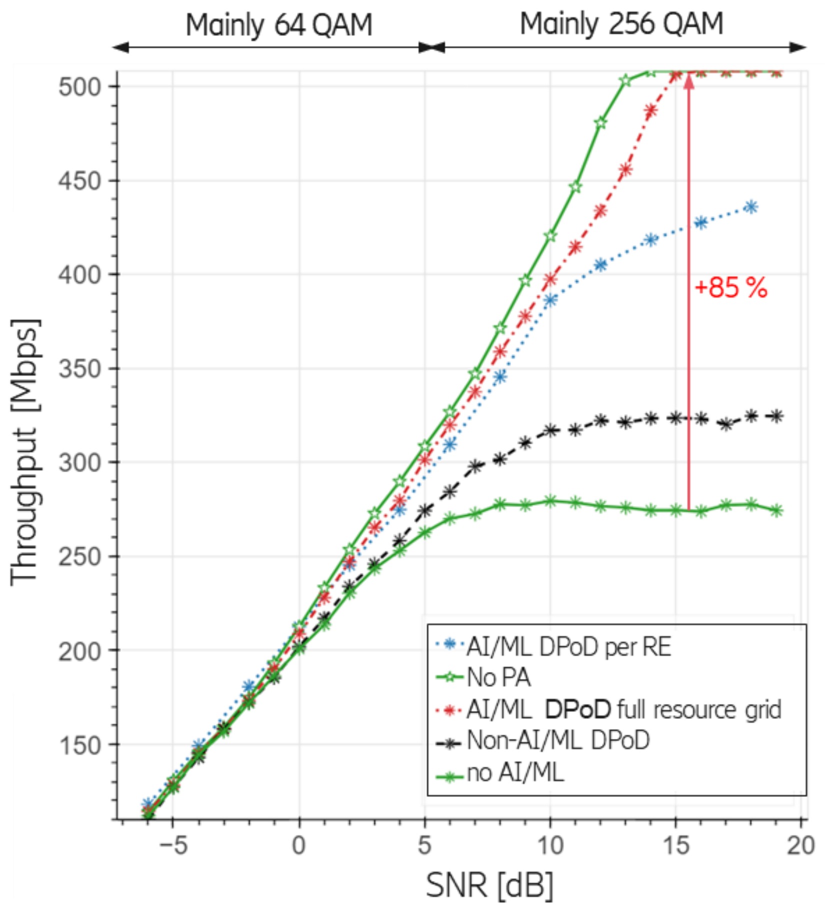


- One-sided (AI in the base station)
- UL is generally the limiting link in NR and expected to be so in 6G due to the UE output power
- If we allow UEs to transmit with higher power using the same hardware, can the base station compensate for the imperfections introduced?
- Assumption: In-band emissions can be relaxed but regulatory requirements still apply

The journey continues – 6G
Use case – Digital post-distortion

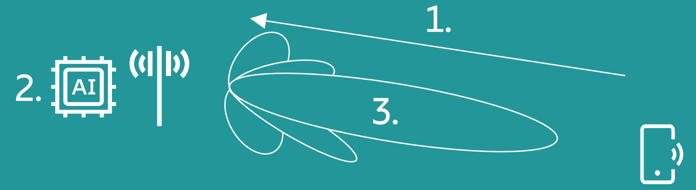
- DFT-s-OFDM scenario in UL for FR2
- Potential gains are seen for higher order modulations
- Performance potential is very much dependent on UE behavior and UE modeling

➢ AI/ML performance could have a strong dependency to other nodes - even with one-sided models



The journey continues – 6G
Use case – SRS channel estimation/prediction

SRS channel estimation/prediction



1. SRS (uplink pilots)
2. AI/ML-based channel estimation
3. Precoding based on AI/ML channel estimate

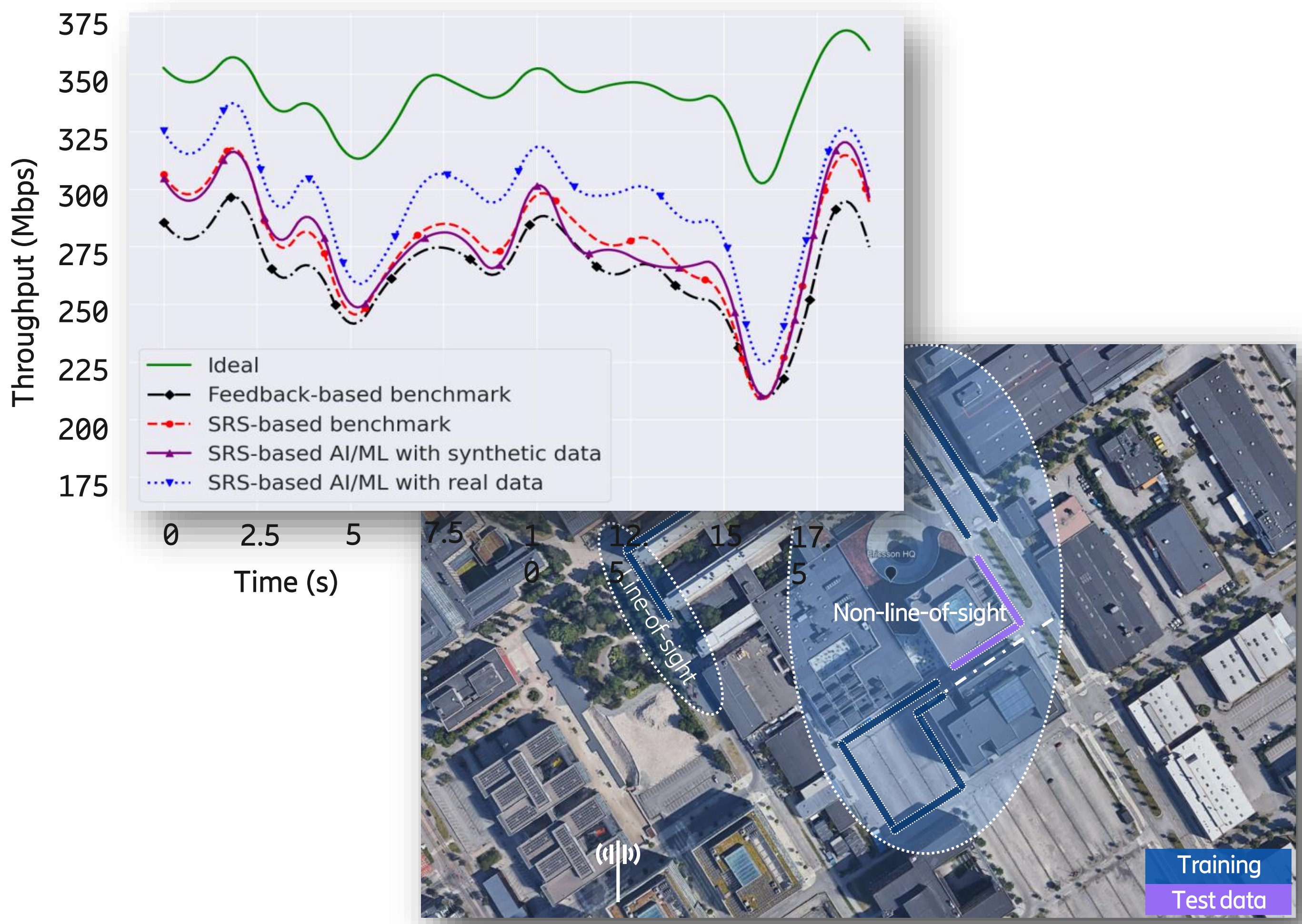
- One-sided (AI in the base station)
- Data-driven design that can account for the wireless channel distribution
  - Enhanced denoising
  - Improved prediction capability

The journey continues – 6G

Use case – SRS channel estimation/prediction

- Generalizability is an important aspect of AI/ML models.
- A model trained on synthetic data is exposed to real data.

➢ Simulations take us a long way, but the true values lies in real data



Visualization of the data collection setup
120k SRS samples collected by a 64-port base station

An AI air interface in 6G

Is now the right time? – Digital twins

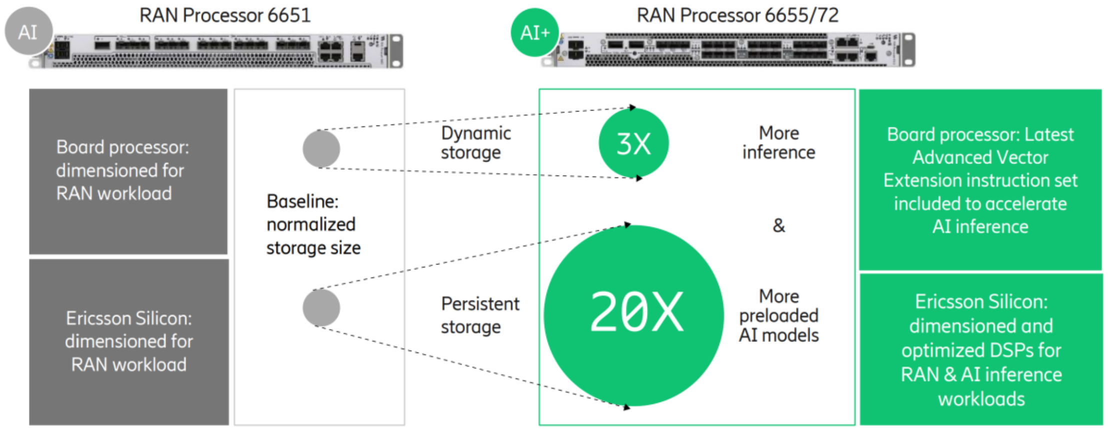
- Digital twins of the real world are becoming a reality
- This opens up for an effective means to acquire realistic diverse data sets for model training and inference
- AI/ML models can be be trained in specialized conditions or tested in unseen conditions to understand ability to generalize

An AI air interface in 6G

Is now the right time? – Improved product support

- The hardware capabilities to support AI workloads are quickly evolving with support in both UE/chipset and network node
  - Qualcomm has had dedicated support for AI PHY workloads since 2022
  - Ericsson continuously improves on the support for AI workloads in the RAN product offering

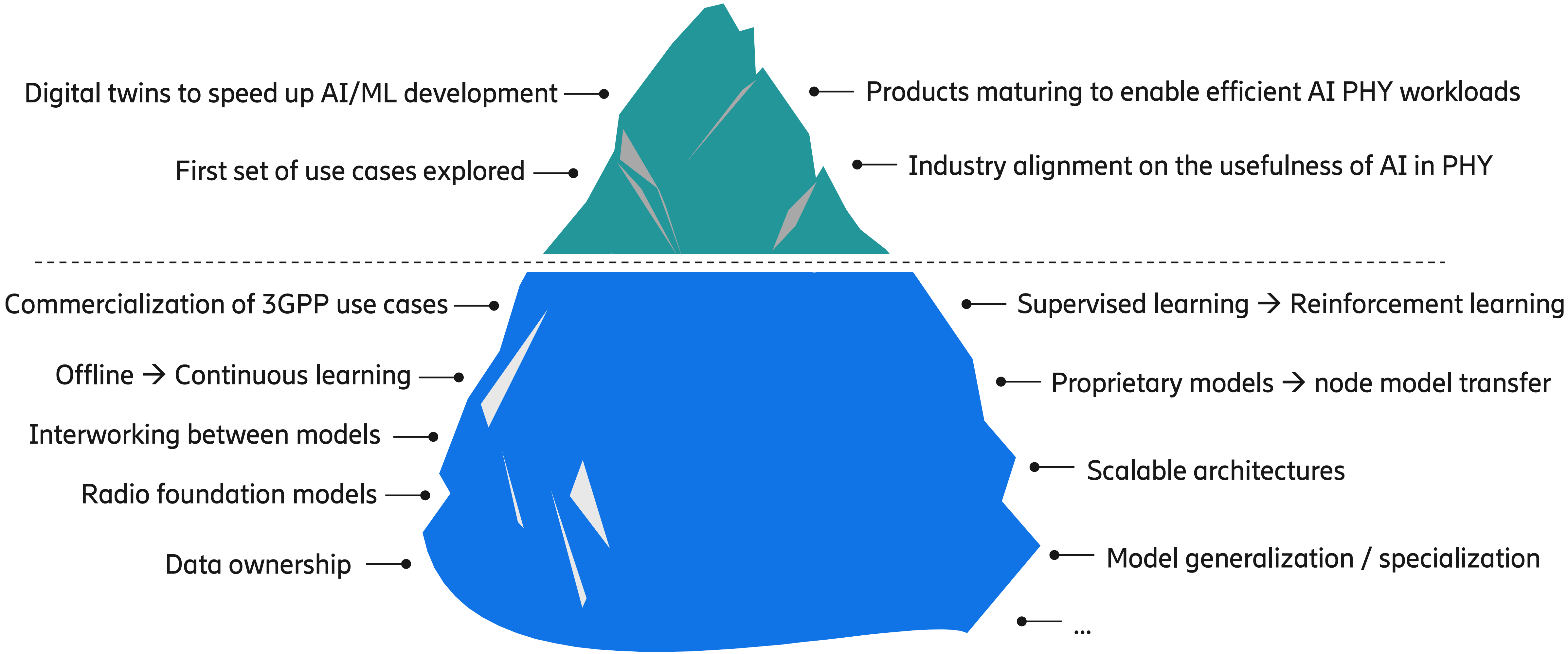
Qualcomm's Snapdragon 8, Gen 5, 2025 [11]



Ericsson report: AI value in RAN [2]

An AI air interface in 6G

The road ahead



An AI air interface in 6G
Concluding remarks

Findings so far

- Performance evolutionary rather than revolutionary (with exceptions!)
- Put trust in simulated data, but real data is king
- Know your baseline!
- Understand the full radio link (not just your own node)
- Distributed AI models amongst nodes are complex!
- Products & tools are maturing - paving the way for integration of use cases in the field

Will 6G be the first generation with an AI air interface?

- Non-AI fallback will always be there, with AI features likely as optional add-ons
- The industry need to converge on a set of promising use cases that are evaluated thoroughly, instead of scattered initiatives
- Too cool AI applications are typically too cool to be realistic. The pain needs to be justified by the gain!
  – Prioritize one-sided use cases

Although the industry has worked on an AI air interface for 3-4 years – this journey has just started

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References

[1] RAN Compute – Ericsson portfolio. [Available online] https://www.ericsson.com/en/portfolio/networks/ericsson-radio-system/ran-compute

[2] AI in RAN to enhance network performance of CSPs – Ericsson report. [Available online] https://www.ericsson.com/en/reports-and-papers/further-insights/ai-in-ran

[3] RP-221348, "Study on Artificial Intelligence (AI)/Machine Learning (ML) for NR Air Interface", 3GPP TSG-RAN #96, June 2022.

[4] R1-2302335, "Evaluation of AI/ML for Positioning Accuracy Enhancement," Ericsson, 3GPP TSG-RAN WG1 #112b, April 2023.

[5] R1-2304749, "Evaluation of AIML for beam management", Ericsson, 3GPP TSG-RAN WG1 #113, May 2023.

[6] RP-234039, "New WID on Artificial Intelligence/Machine Learning for NR Air Interface", 3GPP TSG-RAN #102, Dec. 2023

[7] RP-243245, "Study on Artificial Intelligence (AI)/Machine Learning (ML) for NR air interface Phase 2", 3GPP TRG-RAN #106, Dec. 2024

[8] RP-251870, "Artificial Intelligence (AI)/Machine Learning (ML) for NR air interface enhancements", 3GPP TSG-RAN #108, June 2025

[9] RP-251881, "Study on 6G Radio", 3GPP TSG-RAN #108, June 2025

[10] 3GPP TR 38.843, "Study on Artificial Intelligence (AI)/Machine Learning (ML) for NR air interface (Release 19)," V19.0, Sept. 2025.

[11] Snapdragon 8, Gen 5 product brief

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